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Petroleum Refiner

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JUNE 1957

Handbook to Cathodic Protection 115

- How it works
- Where to install
- What it costs

PIPE SAVING

Reactors Float on Ball Bearings 129

NEW PLANT

How TB&CC Produces Butadiene 143

HIGH STAKES

How to Rate Public Relations 236

For a "Quick Look" at this issue, turn the page . .

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This YARWAY IMPULSE STEAM TRAP is for extra heavy condensate loads

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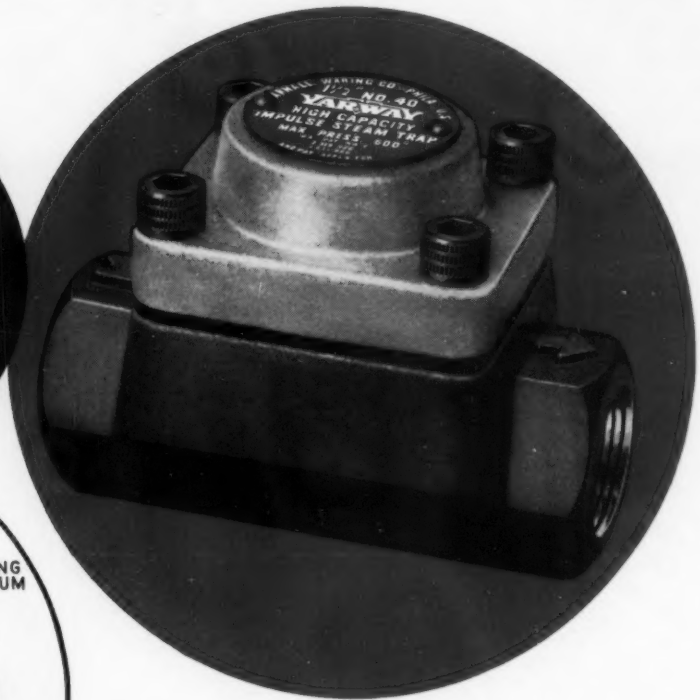

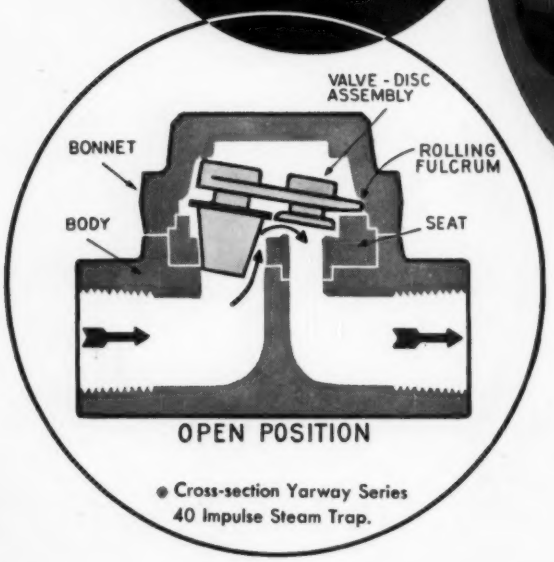

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Petroleum Refiner

REFINING • PETROCHEMICALS • NATURAL GASOLINE

A Quick Look

at This Issue

These handy digests permit checking those articles you want to read first. ☑

☐ **Cathodic Protection Handbook . . .** Here's a practical, down-to-earth digest of cathodic protection activities in a large chemical plant. The article contains enough theory to refresh the reader's memory, with the balance being devoted to aspects of how cathodic protection is applied and what it costs. For complete details, turn to Page 115.

☐ **Reactors Can "Float"—On Ball Bearings! . . .** Here's a unique system of design that minimizes the amount of alloy piping necessary for flexibility between reactors and heaters. Turn to Page 129.

☐ **Minimum Velocity for Catalyst Flow . . .** A critical factor in the designing of catalyst conveying systems is determining the minimum velocity to prevent saltation (in horizontal tubes) and choking (in vertical tubes). Correlations are presented, along with previously published data, tying actual operational practice and experimental data together. From this it is possible to predict behavior in catalyst systems. Clip this for your design workbook. Turn to Page 133.

☐ **First Postwar Butadiene Plant . . .** For the first time three well known commercial processes are combined to produce butadiene and alkylate gasoline. Direct butane dehydrogenation provides feed for the furfural extraction unit as well as furnishing butylenes for the sulfuric acid alkylation unit. Turn to Page 143.

Please Turn Page ➡

A Quick Look at This Issue . . .

☐ **How Tidewater Built Newest Refinery . . .** In its new refinery, Tidewater has six units which are the largest in the world. Other special features in this "refinery of the future" are described in the article on **Page 148.**

☐ **Where and Why Tidewater Used Alloys . . .** When a variety of crudes must be processed, the best time to plan for corrosion is in the beginning. Tidewater designed for minimum corrosion problems from the start by the proper use of alloys. For where, why and how much, turn to **Page 150.**

☐ **Where Tidewater Used New Instruments . . .** In its Delaware refinery design, Tidewater had a wide choice of revolutionary instrument designs. Here is what they considered and why they picked data loggers and scanners to form complete information systems at each unit. Turn to **Page 157.**

☐ **Amoco's New Yorktown Refinery . . .** Here's a rundown on what's inside American Oil Company's new refinery. Throughout the planning, engineering and construction provisions for future expansion were considered. Good community relations were insured by installing elaborate effluent treating facilities. For a quick look at this refinery with a future, turn to **Page 155.**

☐ **Liquid and Gas Pressure Drops by Nomogram . . .** You can save time and effort with these nomograms for your fluid flow calculations. Calculate the pressure drops and the velocities this easy way. You can also use one of these nomograms to determine the specific volumes of gases and vapors. This is another one for your data book. Turn to **Page 158.**

☐ **How to Figure Minimum Reflux . . .** Here is a practical method to calculate accurately the minimum reflux in multicomponent distillation systems. The method is not based on the usual limiting assumptions of constant relative volatility and constant molal overflow. Check it over by turning to **Page 161.**

☐ **A New Approach to Maintenance Controls—Part 2 . . .** Tolerable maintenance limits may be calculated so that you may avoid unadvised repairs, run a better balanced replacement program and reduce the risk of breakdowns and high maintenance costs. For complete details, turn to **Page 171.**

☐ **Eliminate steam tracer lines** with this new method for maintaining a constant temperature in refinery piping systems. Turn to **Page 175.**

☐ **Set Conditions for Hydrogen Treating . . .** The authors have made an exhaustive study of Hydrofining a thermally cracked naphtha. They show how it is possible to predict the diene and olefin content and octane numbers of products from selective hydrogenation. Learn how they correlate the operating conditions by turning to **Page 179.**

☐ **How to Test Absorbers . . .** Here's a proposed AIChE Standard that outlines the procedure for testing performance of absorbers. For complete details, turn to **Page 187.**

☐ **Centrifugal Pump Packings and Seals (Part 5) . . .** Included with this report on installation and maintenance is a guide to packing troubles, their cause and cure. Turn to **Page 193.**

☐ **How to Predict the Solubility of Water in Hydrocarbons . . .** With little effort you can use this focal point method to extend and estimate solubility data. This is a good one for your files. See **Page 198.**

☐ **Why Centralized Training? . . .** More than half of the larger oil companies are using central training sections. Are they paying their way? How are they organized and operated? These two important questions are answered in full in this comprehensive survey of 50 oil companies. Turn to **Page 231.**

☐ **How Do Your Public Relations Rate? . . .** Here is an excellent yardstick to use in evaluating the success of a refinery public relations program. This check list of 50 questions will be of particular help to executives, supervisors, foremen and engineers. Pass copies around in your refinery as another reminder of the importance of public relations to your operation. Turn to **Page 236.**

☐ **Controlling High Vapor Pressure Fires . . .** Using actual case histories, one of the nation's top oil fire authorities outlines the precautions to take in storing high vapor pressure products—then describes the most successful methods of fire control for such products. A comprehensive analysis of these case histories and methods, including discussion of product characteristics, plus proper layout, design and construction of high vapor pressure product containers, is to be found on **Page 240.**

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PETROLEUM REFINER and The REFINERY CATALOG for the refining, natural gasoline, petrochemical industry.

WORLD OIL (formerly The Oil Weekly) and The COMPOSITE CATALOG for the drilling-producing industry

PIPE LINE INDUSTRY and The PIPE LINE COMPOSITE CATALOG (first edition to be issued in July, 1957) for the oil and gas pipe line industry.

Petroleum Refiner is indexed by Industrial Arts Index, Chemical Abstracts and by Engineering Index, Inc. Microfilm copies available through University Microfilms, Ann Arbor, Michigan.

Special PR Dishes

YOU VERY LIKELY will be interested to a high degree in the Cathodic Protection Handbook, a 14-page deal that starts on Page 115 of this issue. Written expressly for PR by five of the top men in the Texas Division of The Dow Chemical Company's electrochemical department, it tells what cathodic protection is, where and how to use it, how to design a system for your plant and how much it costs. If extra copies are needed, reprints are available at a nominal price.

On the back burner called July we have a special report on Separation Methods. Included in the topics which will be discussed are thermal diffusion, solvent extraction, extractive crystallization and selective adsorption. Description of these more or less uncommon methods of separation should be of real reader value.

Now Hear This—

SINCE LAST WE REGALED the readers of Page 5, PETROLEUM REFINER has been honored through receipt of two outstanding editorial excellence awards. We would give a listen if your daughter won a swimming match or the grandson pulled a cutie; so how about lending your ears for a few moments while we tell you about:

- Don Lambert, our Management and Personnel editor, on April 17 was presented an award of merit in the Third Annual Jesse H. Neal Editorial Achievement competition conducted by the Associated Business Publications organization. Don's excellent series on oil industry public relations was judged a top-ranker among the entries for outstanding accomplishment during 1956 on the part of an individual editor.
- Then in New York on June 10 PETROLEUM REFINER was awarded a Certificate of Merit in the Industrial Marketing Contest for the "Best Single Issue" of 1956. This tap on the shoulder was for our Process Handbook of September, 1956, an issue that was engineered by that ol' engineer himself, Harold Hoffman. Competition was pretty rough this year with 653 entries. Three years ago PR won a similar certificate for its Petrochemical Process Handbook.

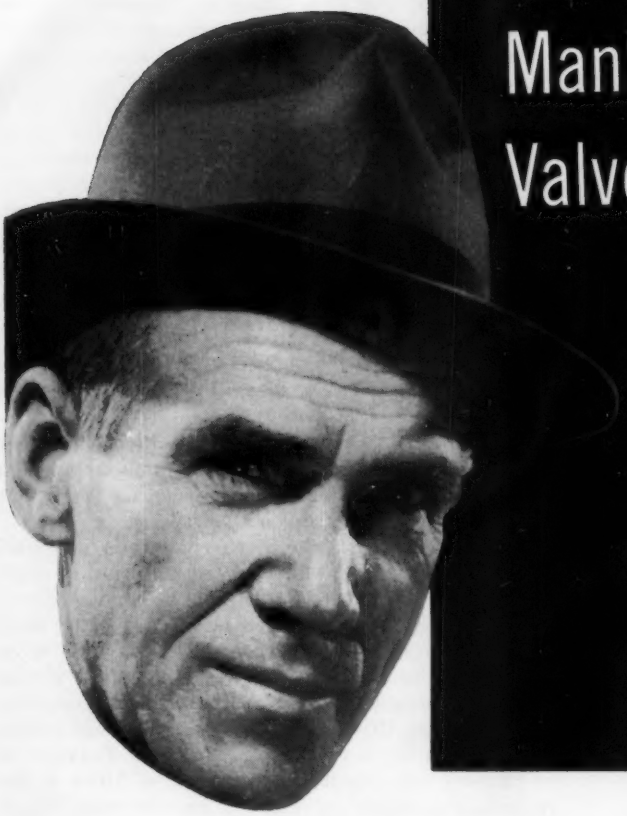
We are sure our readers share the pride in PR's editorial excellence which these awards confirm.

Second to None

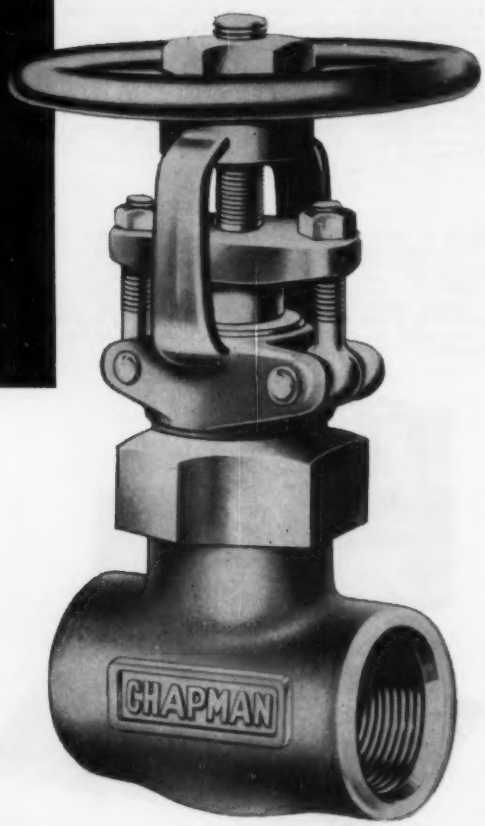
A FEW WEEKS BACK the PETROLEUM REFINER staff, including our district men, held a family-style conference in Houston. One of the highlights was a talk by Publisher R. L. Dudley on PR's aspirations. In his talk he touched on five main points (and much more space could be devoted profitably to each one than we have here for the whole) which we'd like to share with our readers. Our aim to continue to be second to NO magazine in our particular field. Certainly then we want to be (1) most useful, (2) complete, (3) authentic, (4) specialized and (5) most readable.

You will be hearing more of these aspirations as we go along, but here and now we wanted to let you in on what our continuing plans embrace.

Valve Man's Valve...



CHAPMAN
LIST 960 SMALL FORGED STEEL GATE VALVE



There are good reasons why men-in-the-know specify Chapman List 960 for more jobs than other small forged steel gate valves. These reasons concern two important points . . . (1) long-range performance and (2) low-cost maintenance.

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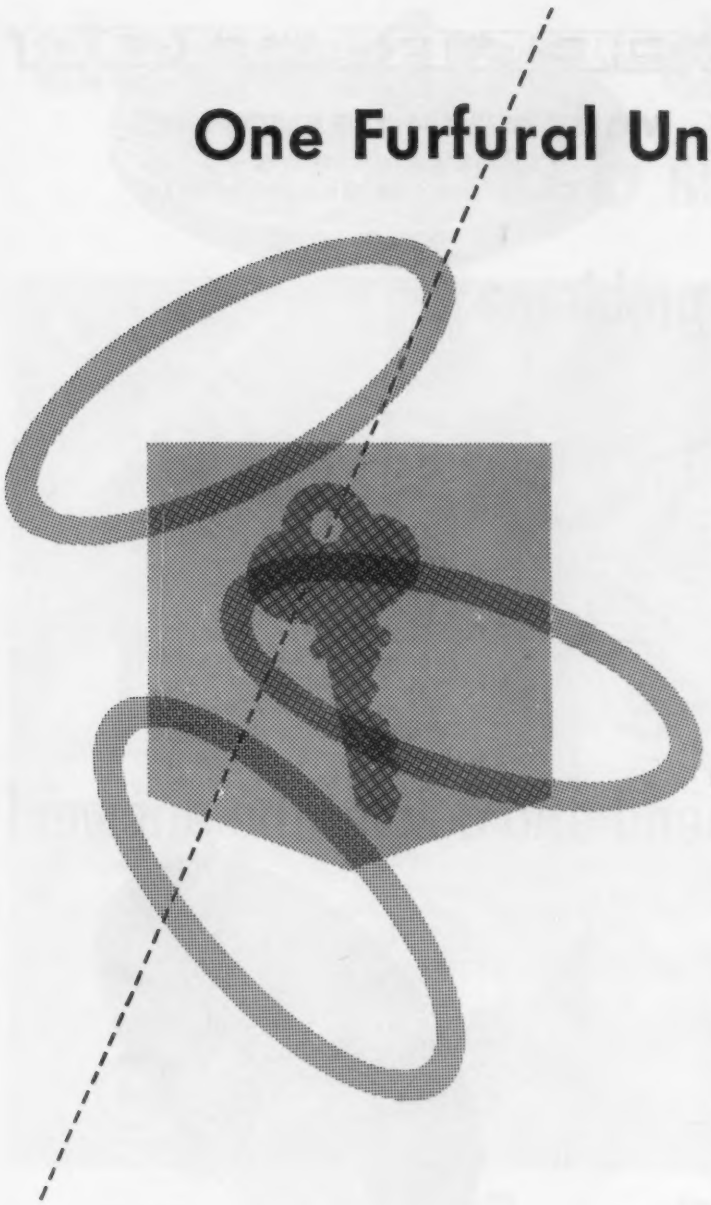
One Furfural Unit Refines All 3



- **LUBE OIL**
- **GAS OIL**
- **CYCLE STOCK**

Furfural has gained widespread recognition as a selective solvent in processing lube oil, and now is used to treat both virgin gas oil and cat cracker cycle oil. One of the outstanding features is that a furfural unit can be used alternately for refining lube, gas oil and cycle stock. Three companies are already using their furfural units for treating both lube oil and cycle stock; forty-two other users of furfural in the petroleum industry can do the same.

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Write for our Bulletin 203-A
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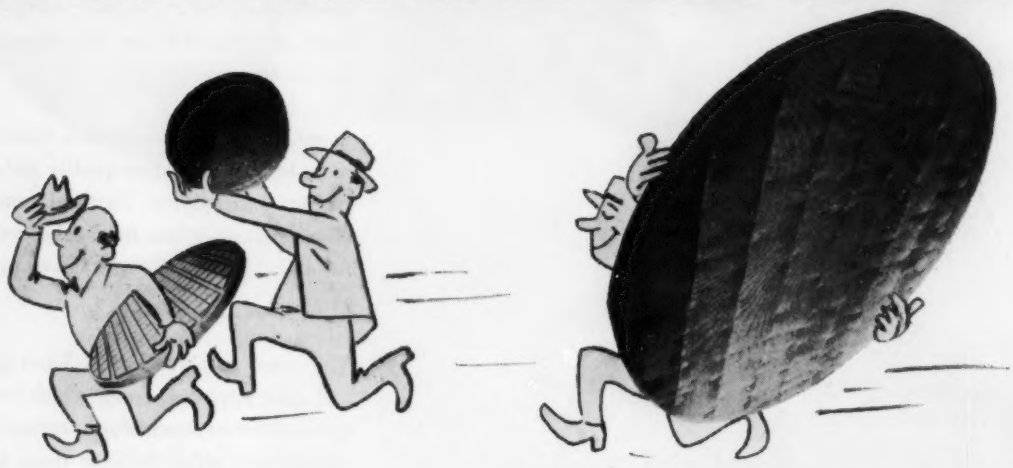

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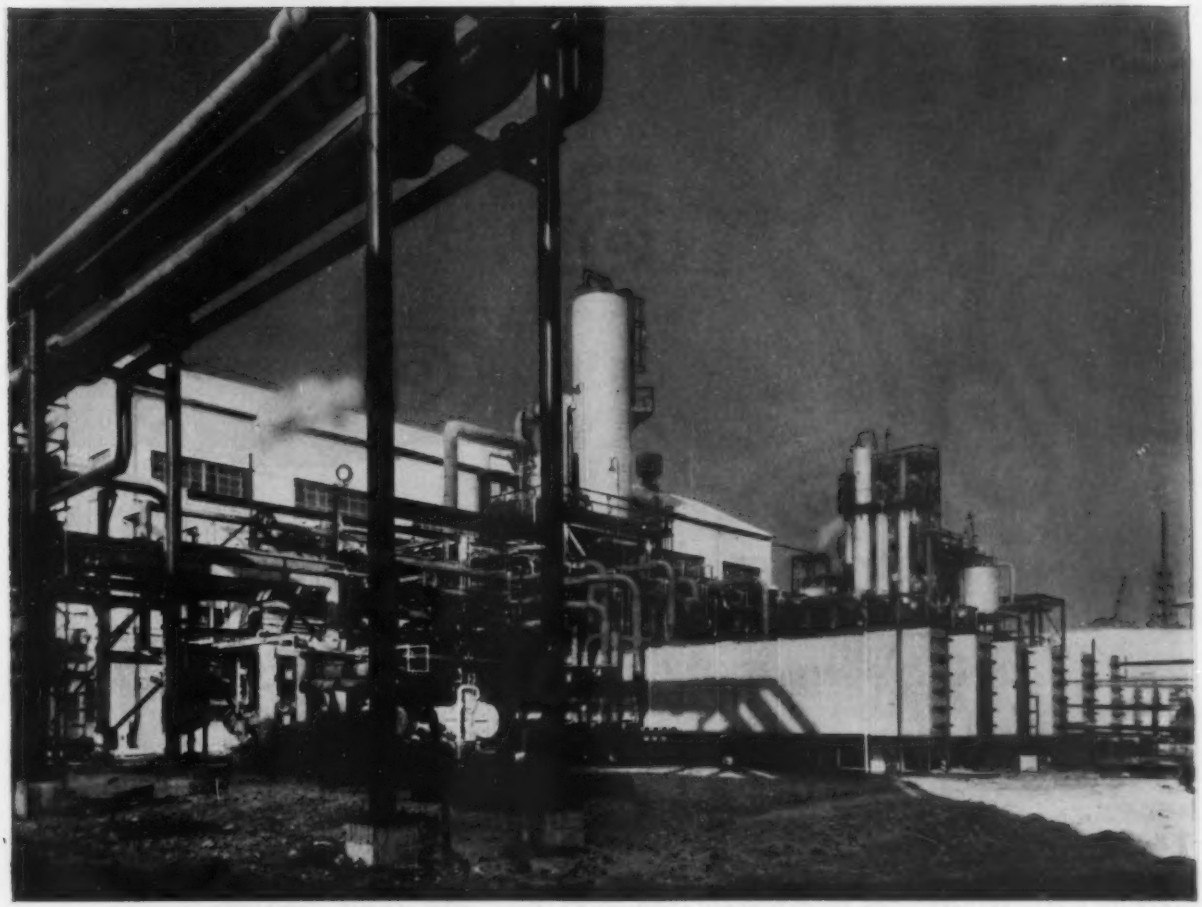

RECENTLY completed for a large Midwestern refiner, this modern MEK Dewaxing-Deoiling plant will process in blocked operation both waxy distillates for wax removal and oily waxes for oil extraction. It is designed to produce zero and lower pour point oils and waxes meeting trade oil content specifications. Foster Wheeler supplied process and mechanical design, engineering and construction.

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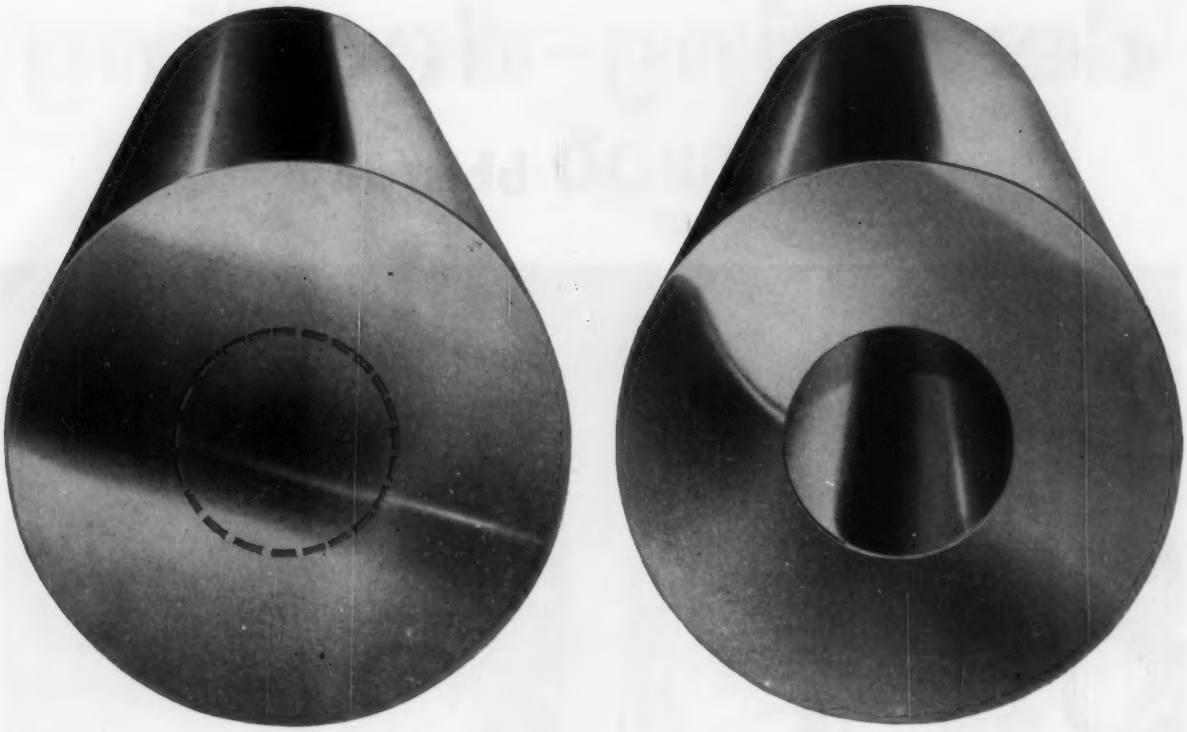

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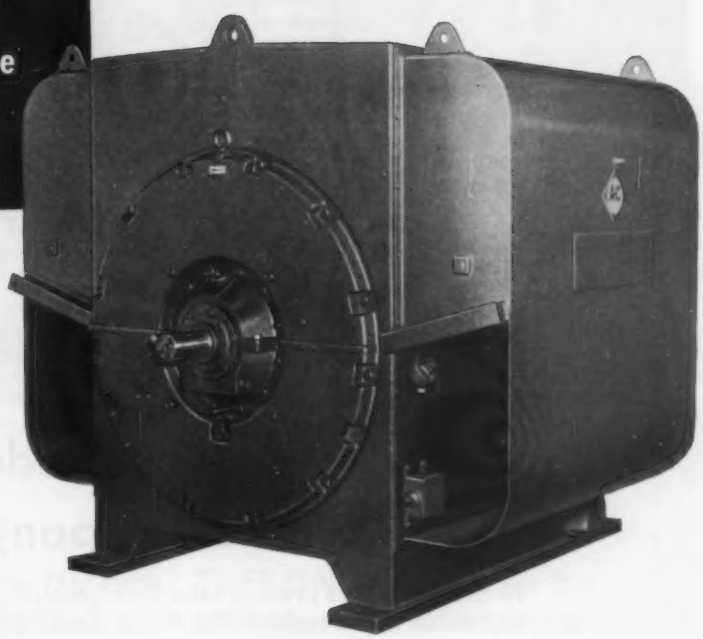

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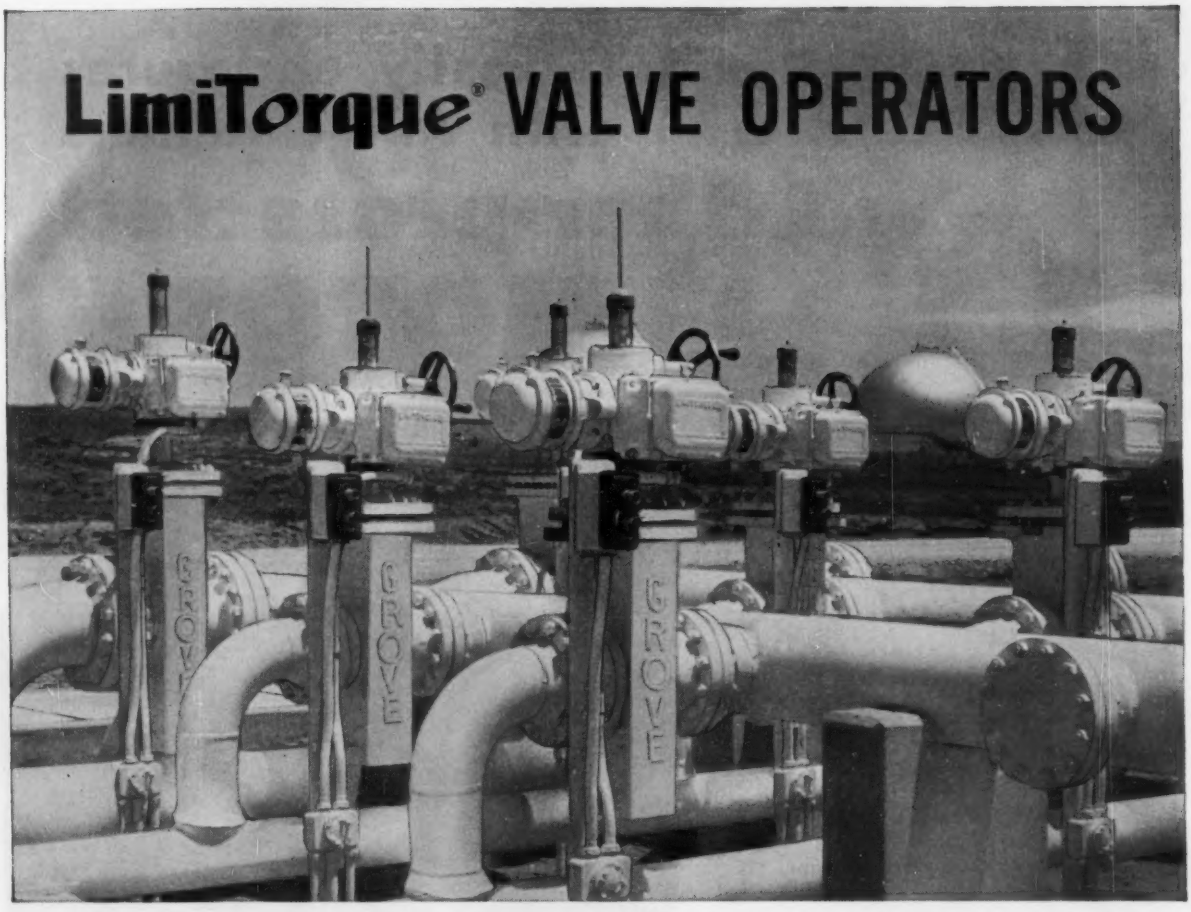

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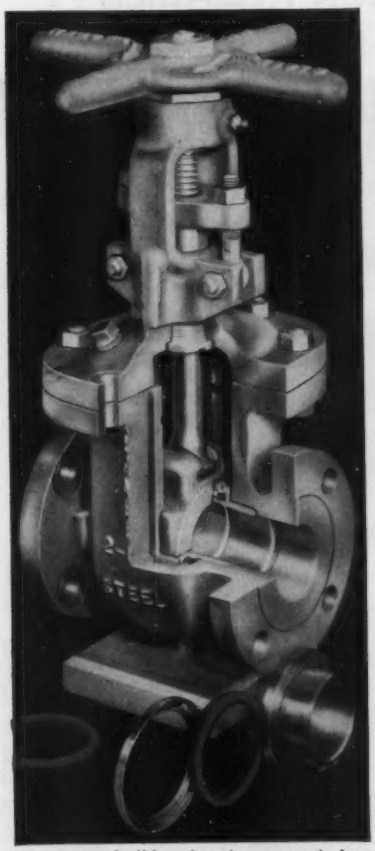
LATEST PROPERTY AND APPLICATION DATA ON TEFLON® tetrafluoroethylene resins

Superior sealant properties of TEFLON® resins prevent losses... reduce maintenance



SEAL RINGS in this gate valve are made from one of the TEFLON tetrafluoroethylene resins. Natural lubricity of TEFLON decreases torque needed to open valve and eliminates sticking or freezing. TEFLON is chemically inert, even at high temperatures. (Valve manufactured by Hamer Valves Inc., Long Beach, California.)

Seals, gaskets and packings of Du Pont TEFLON tetrafluoroethylene resins give outstanding service in pipelines and process equipment. Sealing devices of TEFLON have amazing durability, even under the most adverse conditions.

In the case of the gate valve pictured, TEFLON was selected after consideration of several seal materials. TEFLON is specified because of chemical inertness, lack of tendency to swell or crack, its toughness and durability. TEFLON provides a tight, leakproof seating for the gate. Valve operation is more efficient, and maintenance costs are sharply reduced.

Most of the mechanical strength properties of molded TEFLON 1 or TEFLON 5 are comparable with those of the best grades of rubber-bonded compressed asbestos. In addition, TEFLON has a naturally slippery surface, which facilitates operation of mechanical parts. Designers take advantage of this property of TEFLON to make "self-lubricating" bearings and bushings. TEFLON resins are tough and strong, and are used to make structural elements. Rated for use up to 500°F., TEFLON shows no brittleness at temperatures as low as that of liquid helium.

Du Pont TEFLON resins are unaffected by petroleum distillation products, catalysts and reagents. It is completely inert to acids, aliphatics, aromatics, chlorinated hydrocarbons—virtually all chemicals and solvents in commercial use. The few exceptions to this include attack by the alkali metals under certain conditions. At high temperatures and pressures, halogens and certain halogenated chemicals and solvents may also affect TEFLON.

The next time design of a juncture or closure presents problems of leakage and excessive maintenance, look into the possibility of using Du Pont TEFLON tetrafluoroethylene resins. Additional material on this subject is available. Just mail the coupon.

Now Du Pont TEFLON® resins can be bonded with commercial adhesives

A new, special technique has been developed to alter the surface of TEFLON resins so that commercial adhesives will bond to it. This opens up new ways to take advantage of the remarkable properties of TEFLON. Large surface areas can now readily be covered with TEFLON. Tanks, vats, pipes and digesters can be lined with this extremely inert engineering plastic to achieve exceptional chemical resistance at working temperatures as high as 500°F.

Good bonding strength is attainable between treated TEFLON and any material that will bond with an adhesive. Pressure-sensitive adhesives are used. TEFLON may be used as low-friction facings on hoppers and conveyer surfaces.

Details of this development and its applications are obtainable on request. Use the coupon below.

TEFLON®

is a registered trademark . . .

TEFLON is the registered trademark for Du Pont tetrafluoroethylene resins, and should not be used as an adjective to describe any other product or any component part; nor may this registered trademark be used in whole, or in part, as a trade name for any other product.

SEND FOR INFORMATION

Mail this coupon for additional property and application data on TEFLON.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.
Room 366, Du Pont Building, Wilmington 98, Delaware

Please send me more information on Du Pont TEFLON tetrafluoroethylene resins. I am interested in evaluating this material for

_____

Name_____

Company_____ Position_____

Street_____

City_____ State_____

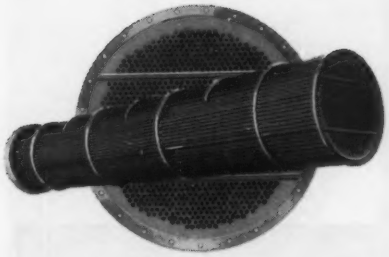
Type of Business_____

In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec

RETUBE YOUR BUNDLES WITH

PHELPS DODGE HEAT EXCHANGER AND CONDENSER TUBES

FOR LONG-RUN RELIABILITY!



- Wide range of finest quality copper-base alloys—bi-metal combinations—to fit your application needs.
- Well-stocked, nation-wide warehouses at Houston, Tulsa, Los Angeles and Bayway, N. J.
- Experienced engineering staff at your service to help solve tube corrosion problems.

Specify Phelps Dodge . . . a leading manufacturer of tubes for the fabricators of heat exchangers and condensers!

PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!

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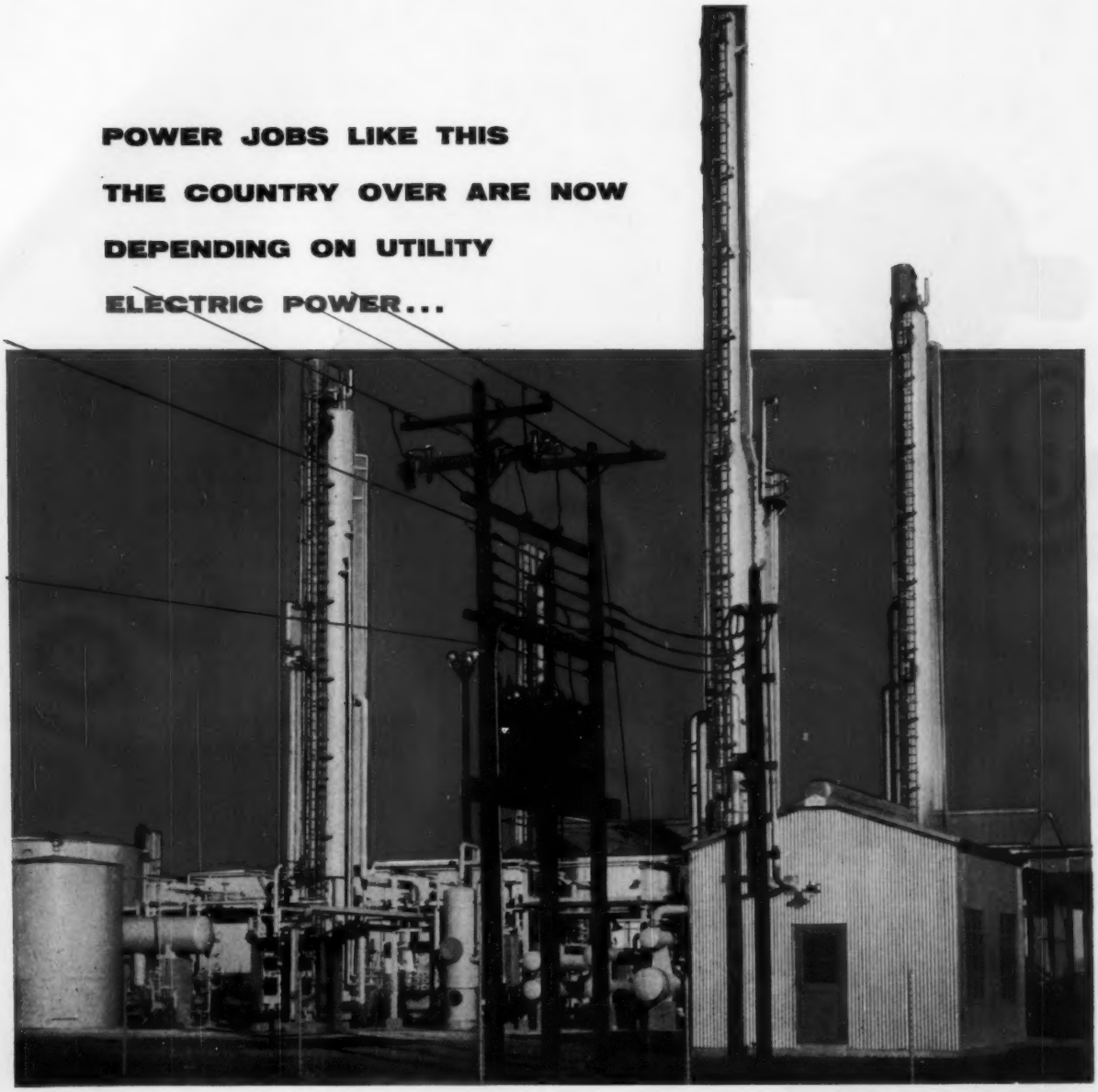
POWER JOBS LIKE THIS THE COUNTRY OVER ARE NOW DEPENDING ON UTILITY ELECTRIC POWER...



Progressive Management is taking a second look

One of the biggest expansions in refining operations is coming up. If you have any part in this important development don't let your company decide on power until the modern benefits of UTILITY ELECTRIC POWER have been carefully investigated. Call in the sales engineer of your Electric Service Company while your plant is in the planning stage. Convincing facts and helpful counsel are yours for the asking.

Be modern . . . Be progressive . . .
Use UTILITY ELECTRIC POWER.

PETROLEUM ELECTRIC POWER ASSOCIATION

P. O. BOX 2771 DALLAS, TEXAS

. MR. ALEX PANCRAZI (left), Pisa Univ. (Italy) graduate, Chief Chemist, Eastern Wine Corp., Bronx, N.Y. (Right), Michael De Piano, N.Y. representative, Cooper Alloy Corp.

PANCRAZI OF CHATEAU MARTIN (Eastern Wine Corp.) tells why he specifies "Cooper *Alloy* Only" on stainless steel valves and fittings

Q. Mr. Pancrazi, why have you changed to stainless steel valves and fittings at Chateau Martin?

A. To assure product purity. Other metals can cause minute contamination reducing clarity and brightness; stainless steel does not.

Q. What valve model do you find most suitable?

A. After extensive testing, we picked a renewable-disc inside-screw globe valve—Cooper Alloy only.

Q. Why "Cooper Alloy only"?

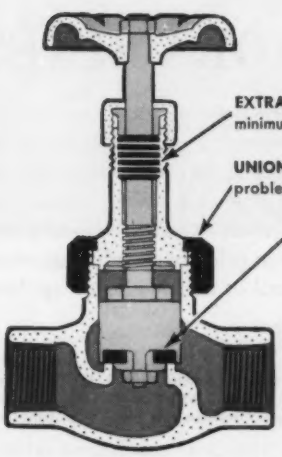
A. Because of three features I find combined nowhere else: renewable retained disc; union-bonnet construction; and extra-deep square-compression stuffing box.

Q. Why is each of these features important?

A. Soft disc gives better seal; retention in metal jacket prolongs its life. When disc replacement is needed, union-type bonnet eliminates difficulties normally found in screwed-in bonnets, removes another threaded joint from product contact. Extra-deep stuffing box with unique square compression reduces maintenance, gives tighter seal at stem.

Q. Don't any competitive valves possess these features?

A. Not one has them all. That's why, to maintain our product contamination-free and to reduce maintenance costs, we insist on "Cooper Alloy only."


EXTRA-DEEP STUFFING BOX holds minimum 6 turns Blue African asbestos
UNION BONNET JOINT eliminates problems found in screwed-in bonnets
RETAINED RENEWABLE DISC for tight seal and long life
COOPER ALLOY Figure 15RD Globe Valve, inside screw rising stem, 200-lb. service, screwed ends, renewable retained disc of composition you specify.

YEARS AHEAD IN DESIGN SUPERIORITY! No matter what your valve type—globes, gates, angles, checks, or Y's—the Cooper Alloy model's outstanding design features will be important to you. Cooper Alloy, with 35 years of pioneering experience in stainless steel, does not merely adapt existing brass and iron valve patterns; it creates valves *designed to be cast in stainless!* **Check the special design features of valve shown at left.**

As the little CA man below is saying: "*You Can Tell A Cooper Alloy Valve As Far As You Can See It!*" Write today for *your* copy of our folder "Design Factors In Stainless Steel Valves." The Cooper Alloy distributor near you will be glad to show you the complete line of Cooper Alloy valves *and fittings*, and their advantages. He can serve you promptly from local stocks.

COOPER ALLOY

Corporation • Hillside, New Jersey

VALVE & FITTING DIVISION

THIRTY-FIVE YEARS OF STAINLESS STEEL PIONEERING

For more data on advertised products, use Readers' Service Cards, last page.

because of GLYCOLS *and* ETHANOLAMINES

Wet or sour gases, once flared as a nuisance, now produce millions in revenue — thanks to the glycols and ethanolamines. If you use these versatile chemicals for gas dehydration or purification, you want to be sure of steady supply and instant service. Allied glycols and ethanolamines are available in tank car lots from Nitrogen Division's Orange, Texas plant, and in tank trucks or drums from warehouses in principal producing areas. Allied's technical specialists are always on call to help with any application problems you may have.

Dept. GA 1-21-2

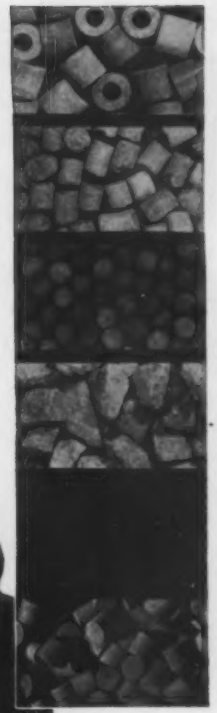
Allied Chemical — Nitrogen Division

40 Rector Street, New York 6, N. Y.

Ethanolamines • Ethylene Oxide • Ethylene Glycols • Urea • Formaldehyde • U. F. Concentrate—85 • Anhydrous Ammonia • Ammonia Liquor • Ammonium Sulfate • Sodium Nitrate • Methanol • Nitrogen Solutions • Nitrogen Tetroxide • Fertilizers & Feed Supplements

HYDROGENATION CATALYSTS

How Girdler helps you solve hydrogenation problems



● There are three important cost-cutting ingredients in Girdler catalyst service for hydrogenation applications:

1. Girdler's *proven hydrogenation catalysts*, such as listed, which are providing optimum operating economy in a wide variety of uses.

2. Girdler's accumulated *technical know-how* which is constantly finding new solutions to difficult hydrogenation problems.

3. Girdler's extensive catalyst *facilities* . . . manufacturing, research, development and technical service . . . which provide the ideal catalyst for *your* application.

Outline your catalyst problem and we will make specific recommendations. Bulletin GC 1256 describes the full line of Girdler catalysts . . . available on request.

NICKEL CATALYSTS	Leaders in the generation and purification of synthesis gases, and for a wide variety of organic hydrogenations. Girdler's close control of reduction and careful selection of support materials impart unique properties for difficult process problems.
COPPER CHROMITE CATALYSTS	One of most highly active and versatile commercial hydrogenation catalysts. Available in regular and barium-stabilized types either as powder or especially strong pellets. Powder meets certain specific particle density requirements.
SELECTIVE HYDROGENATION CATALYSTS	Widely used to selectively hydrogenate acetylenic and diolefinic compounds in purification of olefins. Custom made to give optimum performance with due regard for process variables and contaminants. Facilitate production of high purity olefins for petrochemical processes.
COBALT MOLYBDENUM CATALYSTS	Used extensively by many refineries. Highly active. Developed specifically for sulfur conversion and for hydrogen treating to remove sulfur and nitrogen . . . also for upgrading a wide range of petroleum feed stocks. Excellent physical properties assure high operating economy and long life.
NOBLE METAL CATALYSTS	Pelletized forms of platinum and palladium catalysts for special applications. Advanced techniques produce highly active catalysts, economical both in manufacture and use.

CATALYST DEPARTMENT

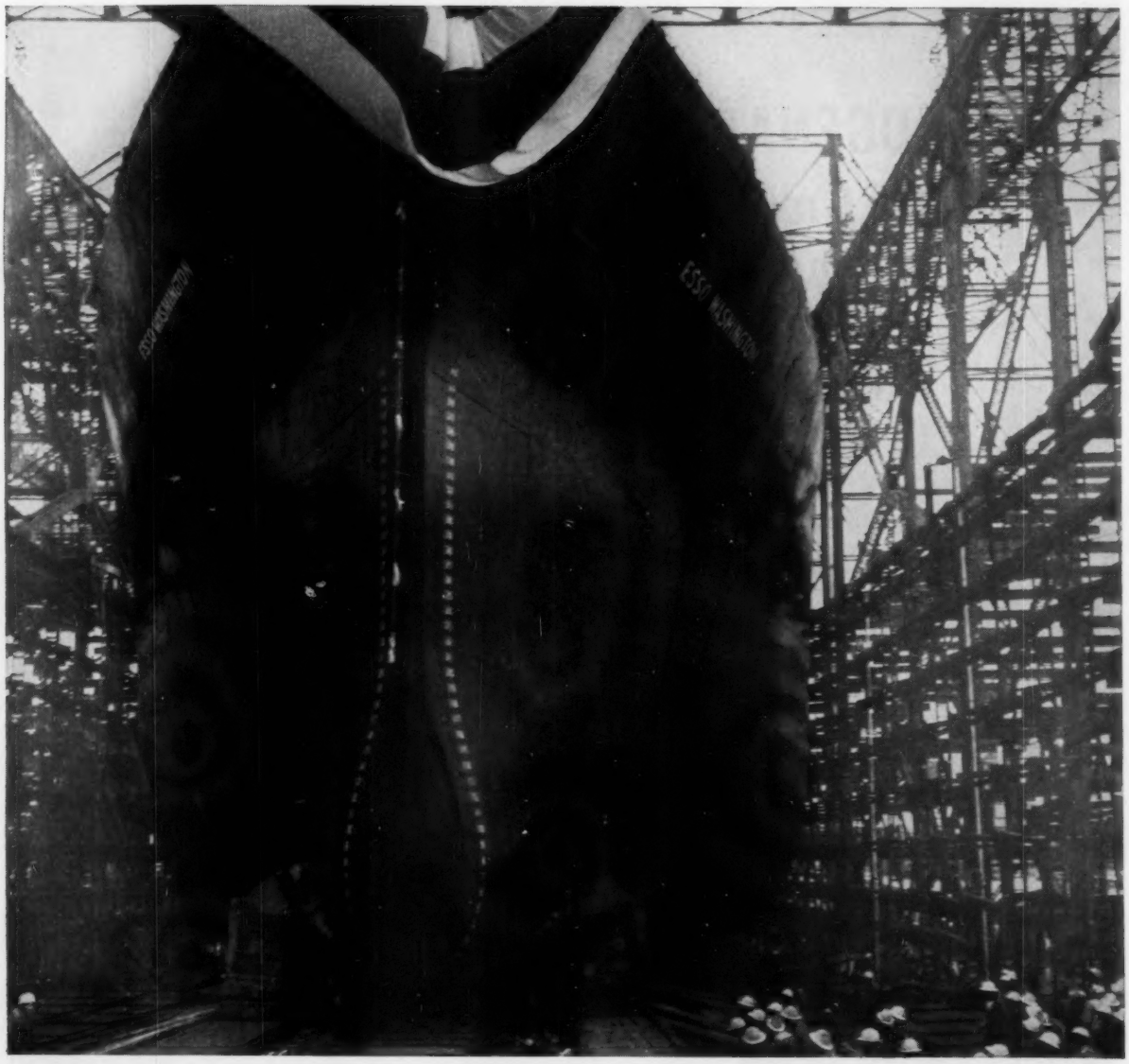
the **GIRDLER** Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

GIRDLER MANUFACTURES CATALYSTS FOR: HYDROGENATION • SYNTHESIS GASES AND HYDROGEN GENERATION • DESULFURIZATION • NEW CATALYTIC PROCESSES

For more data on advertised products, use Readers' Service Cards, last page.



13 MILLION GALLONS BIG...BUT JUST A DROP IN THE BUCKET

The ESSO WASHINGTON is the newest of the 110 ocean-going tankers in the Esso fleets. She can carry 13 million gallons of oil. But that's just a drop in the bucket compared with the 40 billion gallons that Jersey Standard affiliates delivered to customers last year.

As economies expand . . . as populations grow . . . as people live better, oil must provide more energy to power factories, to drive ships and planes and motor vehicles, to heat and light homes and offices. Last year we supplied more than twice the oil we did ten years ago. This year our customers will need still more.

It's a big job . . . and it requires vast amounts of costly equipment. As our Annual Report points out, we spent $1,083,000,000 last year searching for oil and gas and paying for such things as tankers, pipelines and refineries. And in 1957, we plan to spend another $1,250,000,000 to find, produce and deliver the oil people will be needing tomorrow...and ten and twenty years from now.

Because Jersey Standard is willing and able to make such investments and because our operations are efficient, we make a profit. In 1956 it was $808,535,000. About half of it went back into the business to help pay for the new facilities.

Our successful year was good news for the 403,000 shareholders who own the company . . . they got dividends of $2.10 per share on the money they invested.

It was good news for our 156,000 employees . . . whose wages and benefits came to $906,000,000.

It was good news for governments. Operating and income taxes, import duties, consumer taxes and other payments from our operations brought to the United States and other governments a record $2,171,000,000. That was five times the dividends to shareholders, more than double the payroll and benefits to employees.

Best of all, our operations were good news for the people of the free world, who rely heavily on the energy of oil for their economic and social progress.

In this, our 75th anniversary year, we intend to continue our efforts to remain successful, profitable and growing, in order to serve people well.

If you would like a copy of our 1956 Annual Report, write us at Room 1626, 30 Rockefeller Plaza, New York 20, N. Y.

ESSO 75 YEARS

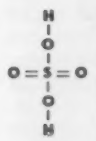
STANDARD OIL COMPANY (NEW JERSEY)
AND AFFILIATED COMPANIES

producing energy for an abundant life

For more data on advertised products, use Readers' Service Cards, last page.

Where lead gives useful corrosion control

in liquid Sulphur Dioxide process vessels and piping

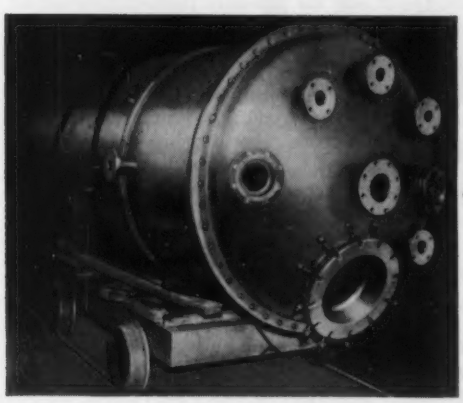


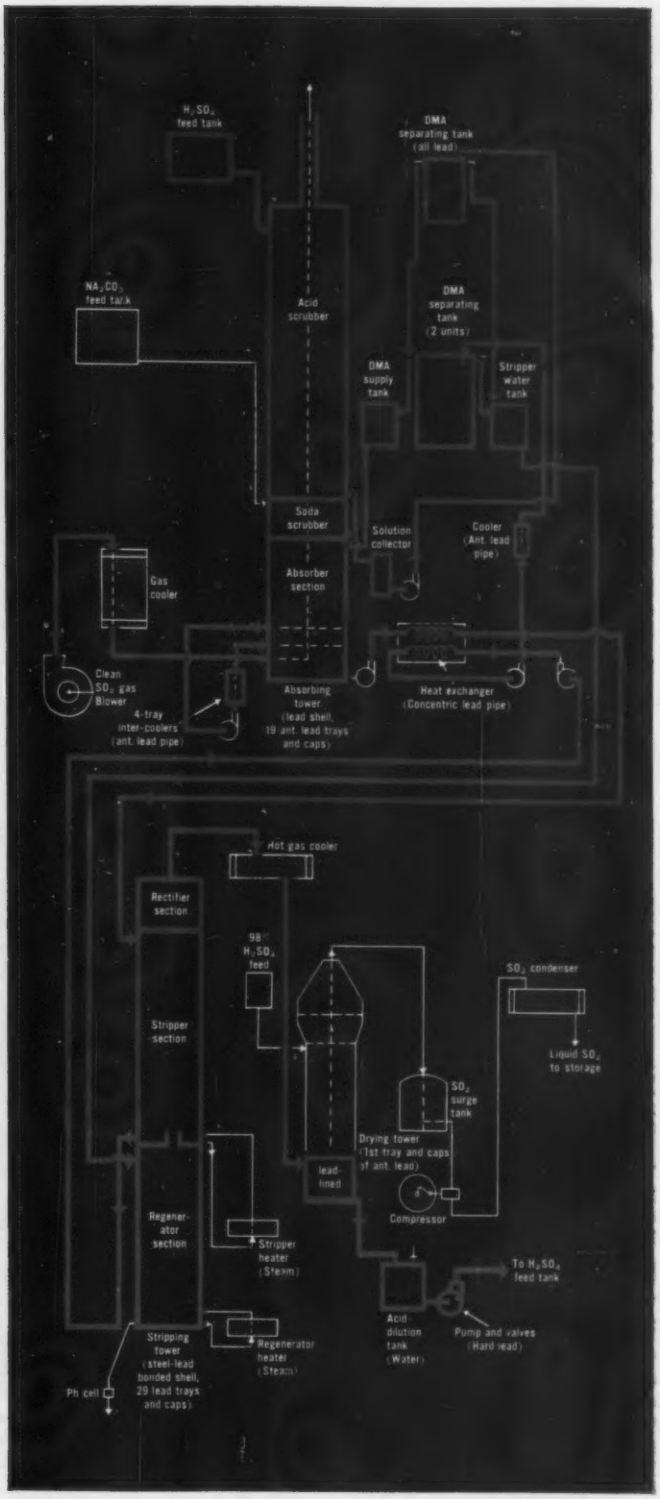
Hot SO_2 vapors and other oxidation products present in liquid SO_2 processing are "murder on metal." Even that old corrosive marauder, H_2SO_4 gets into the act.

As a result, *lead* practically lives with these acids and gases throughout the SO_2 process. In fact, the flow chart at the right is almost a continuous flow of *lead* applications. For ducts. For piping. For sheet lead linings in the larger units like the scrubbers and strippers. It is used with steel, with wood, with copper and, in some cases, with concrete. The result is low maintenance cost, facility of repair and consequent freedom from costly production stoppages.

If your process involves corrosive chemicals, look to *lead* for *long life, low maintenance and minimum loss of production due to down-time.*

When you think of Lead ...*think of* National Lead

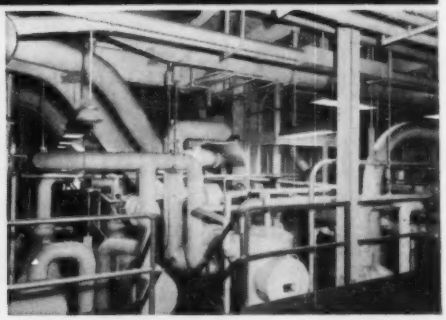




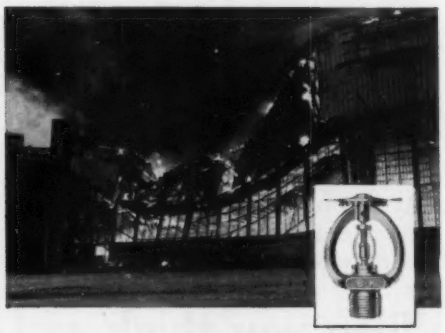
National Lead has the experience to get *lead* and steel together in a *bond* that defies severe pressure and temperature changes, vibration and creep. That's been proved not only in regular production "stock" items such as piping and valves but also in specially designed, complex lead process and storage equipment. If you are enlarging or modernizing your processing facilities, now's a good time to get the facts about lead-lined equipment. Contact National Lead Company, Lead Lined Products, 111 Broadway, New York 6, New York.

For more data on advertised products, use Readers' Service Cards, last page.

BLAW-KNOX has what it takes—to provide these products and services



Heater piping system in this modern generating station is typical of many high temperature, high pressure systems prefabricated and erected by Blaw-Knox. Experienced piping engineers, modern shop facilities and a new Blaw-Knox digital computer method for fast, accurate calculation of piping stresses are available to you. Let us know your requirements and we'll provide the service you need. For more information, write for Bulletin No. 2443—"Piping for Industry."



Out of every 100 firms who lose their records in a fire, 43 never reopen for business. Be safe. Let a Blaw-Knox fire-protection engineer study your needs—and explain how you can pay for the system on our lease or deferred payment plan. To get more information send for Bulletin No. 2426—"Fire Can Destroy Your Business."

Blaw-Knox trapeze functional spring hanger installed in first large atomic generating station. Vital power piping system for the atomic generating unit in the Duquesne Light Company's Shippingport Station is supported by Blaw-Knox custom-engineered hangers.

Blaw-Knox makes a complete line of standard and custom-engineered pipe hangers, supports, and vibration eliminators. Each is a complete packaged unit, designed for a specific purpose and constructed to comply with the "code for pressure piping." Available in types and sizes to meet varying conditions, ready to install.

Blaw-Knox engineers, who have solved many difficult hanger and piping vibration problems, are always available to both design and make recommendations for your hanger requirements. For further information, write for Catalog No. 54.

BLAW-KNOX

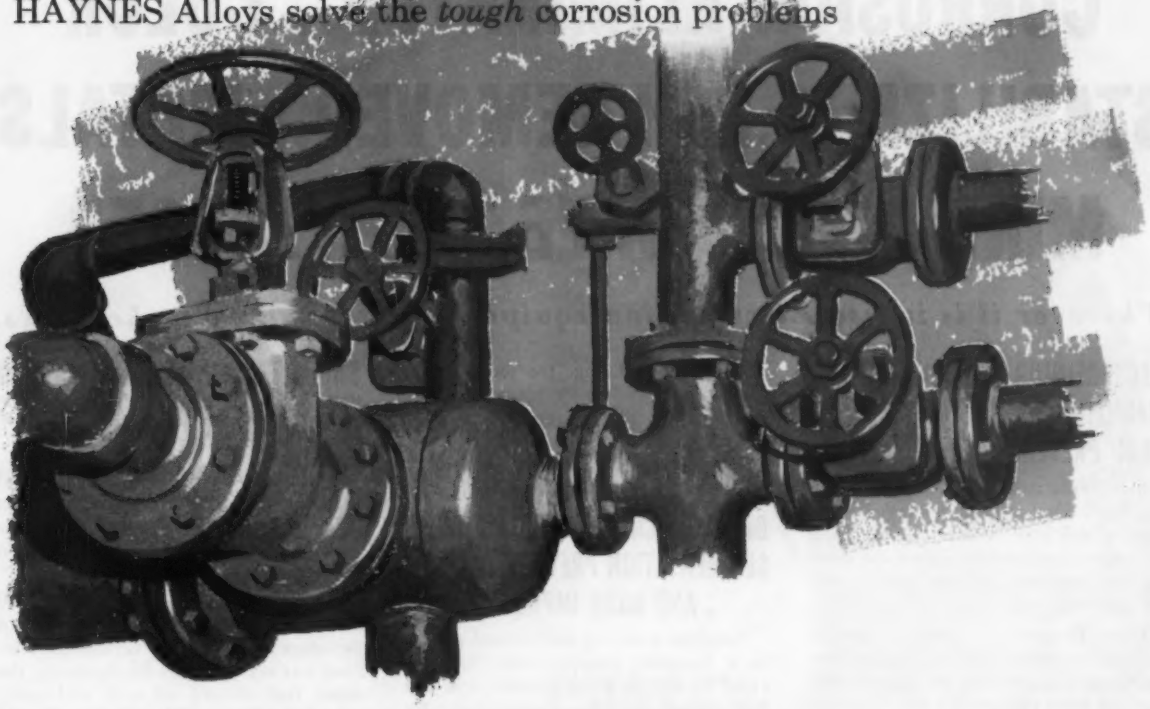
BLAW-KNOX COMPANY

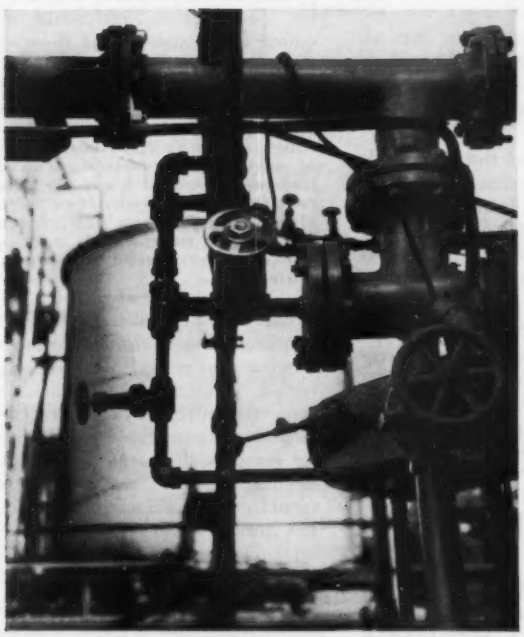
Power Piping and Sprinkler Division

829 Beaver Avenue • Pittsburgh 33, Pennsylvania

Complete facilities for prefabrication and erection of piping systems for all pressures and temperatures
...complete line of standard and custom-engineered pipe hangers, supports and vibration eliminators
...complete line of automatic sprinkler systems for standard and special hazards

HAYNES Alloys solve the *tough* corrosion problems





Valves previously used lasted only a day . . . but alloy B valves exposed to sulphuric acid and live steam while regulating flow from a neutralizer unit are expected to last indefinitely.

Refinery Corrosives Economically Controlled

Aluminum chloride, hydrogen sulphide, sulphuric acid, and other strongly corrosive media usually associated with refinery operations are handled safely and economically by equipment made of HASTELLOY alloys. Complete protection can be assured by specifying HASTELLOY alloys for use in towers, concentrator tubes, heat exchangers, tubing, pipe, pumps, and valves.

There are four HASTELLOY alloys, each specifically designed to resist certain corrosives. One or more of them can solve your corrosion problems, help to lower maintenance costs, and step up production.

For full details on physical and mechanical properties, corrosion data, and fabrication information, send for our newly published 104-page booklet. Write HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation

UNION CARBIDE

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CORROSION ELIMINATED...COLOR STABILIZED...RSH REMOVED...METALS MINIMIZED...HAZE TEST PASSED

Wherever it is in use, Electrofining equipment performance makes news.

ELECTROFINING IMPROVES COLOR STABILITY, REMOVES MERCAPTANS AND PREVENTS SEDIMENTATION

In a Texas refinery the Cat Cycle Oil for No. 2 Fuel needed improved color stability and RSH removal. In addition, the conventional treating in use was causing sedimentation, wasting product and not removing metal ions.

Three Petreco 12′ diameter vertical Electrofiners were installed. The Electrofiners were 2-stage units, set up to caustic treat and water wash, with a daily throughput capacity of 24,000 barrels.

The Electrofining treatment resulted in a color-stable product, reduced the RSH and cut sedimentation and metal ions to minimum. Both caustic and product were saved, and a pollution problem was corrected.

PENNSYLVANIA REFINER SAVES CAUSTIC, PRODUCT AND INHIBITOR WITH ELECTROFINING

A Pennsylvania refiner, treating catalytic gasoline, was bothered by product contamination from organic acid, olefins, diolefins and RSH. One 10′ vertical, 2-stage Electrofiner was installed. It easily handled 12,500 barrels per day, caustic treating and water washing.

After treating with Electrofining, it was found that the Cu dish gum was reduced to specifications, the product was doctor sweet and all engine tests were successfully passed. There also were substantial savings in caustic, gasoline and inhibitor.

A New Jersey refiner recently installed Electrofining equipment to reduce the load on his hydrofiner.

JET FUEL PASSES ALL TESTS AFTER ELECTROFINING

A California refiner installed Electrofining equipment to acid-alkali treat 5,000 barrels per day of jet fuel. One two-stage, 8′ diameter Electrofiner was used, easily handling the required throughput.

After Electrofining, the jet fuel was free of RSH and easily passed all tests. Compared to the conventional treating formerly used, less acid and less caustic were required, and much less product was lost in the treating process.

ORGANIC ACID AND RSH REMOVED-SEDIMENTATION PREVENTED, COLOR AND ODOR IMPROVED

Catalytic cycle oil and natural gas oil in a Canadian refinery were contaminated by tarry acid, naphthenic acid and RSH. Sedimentation was severe and color was not stable.

Three Petreco 10′ diameter, vertical, two-stage Electrofiners were installed. They easily handled the daily throughput requirement, with a caustic and water wash treatment.

Electrofining removed the undesirable acids and RSH. The sedimentation problem was eliminated, and color haze tendencies improved. In addition, product odor was markedly improved. Less caustic was required for treatment and less product was lost.,

A Texas refiner utilizes a 6′ diameter vertical single stage Electrofiner for sulfonation. With it 500 barrels per day of virgin gas oil were sulfonated to yield an improved oil-soluble sulfonate. By using the Electrofiner, a substantial saving in equipment was effected.

PLATFORM CATALYST LIFE IMPROVED, ARSENIC AND LEAD REDUCED, CLAY LIFE LENGTHENED

Two vertical one-stage Electrofiners were installed in an Oklahoma refinery to acid-alkali treat 6,000 barrels per day of straight run naphtha. The platform catalyst was being poisoned by arsenic and lead.

After the Electrofiner was put on stream the arsenic content of the naphtha was reduced from 175 to 5 parts per billion. Lead was cut from 660 to 20 parts per billion and clay life was substantially lengthened.

DT-57-2

SALES ADVANTAGE ATTAINED WHEN DIESEL FUEL PASSES BRITISH FILTER TEST

A Louisiana refinery exporting diesel fuel to Great Britain was encountering difficulties in passing specification tests because of naphthenic acid contamination and sedimentation.

To caustic treat and water wash 9,000 barrels per day of virgin diesel fuel, a two-stage 10′ diameter vertical Electrofiner was set up. After Electrofining, the diesel fuel showed nil acid, and easily passed the British Filter Test and metal ion specifications. Less caustic was required for treatment, and there was no product loss.

In an Ohio refinery, a 6′ diameter Electrofiner is used as an acid precipitator, handling 4,500 barrels per day of alkylation products. Acid sludge fines are removed from the product, resulting in minimized residual sludge. Savings in neutralization agents are substantial, and operational supervision has been cut materially.

Every day Electrofining is being utilized by more and more refiners for specialized treating problems. It is precision controlled, permitting the distillate to be contacted with exactly the correct amount of treating agent, in the proper intensity, for precisely the correct time. Powerful electrostatic forces separate the treating agent from the hydrocarbon phase quickly and cleanly, minimizing entrainment and carry-over, and eliminating over-treatment and side reactions.

For treating distillate stocks to improve color, odor, etc., no processing equipment delivering comparable treating results approaches Petreco Electrofining in low cost and economical operation.

PETRECO®

A DIVISION OF PETROLITE CORPORATION
3202 S. Wayside Drive, Houston 1, Texas
1390 East Burnett St., Long Beach 7, California

Specialized Electric Petroleum Treating

DESALTING • DEHYDRATING • CAUSTIC WASHING
ACID TREATING • DOCTOR TREATING • SWEETENING
NAPHTHENIC ACID REMOVAL • SEDIMENT REMOVAL

No question about it... **CHASE®**

HEAT EXCHANGER TUBES

lower operating costs!

How? By providing peak operating efficiency through many *more* years of service! It's that simple. But not simply arrived at. It takes precise alloying – the addition of the right amount of antimony to *resist* dezincification! It takes severe field and laboratory testing! It takes rigid quality controls! Yes – all this and more to keep Chase Antimonial Admiralty Heat Exchanger Tubes the unquestioned leader. It will pay you to learn about Chase! Write today for your free 54-page manual: *"Chase Condenser and Heat Exchanger Tubes."*

Chase®

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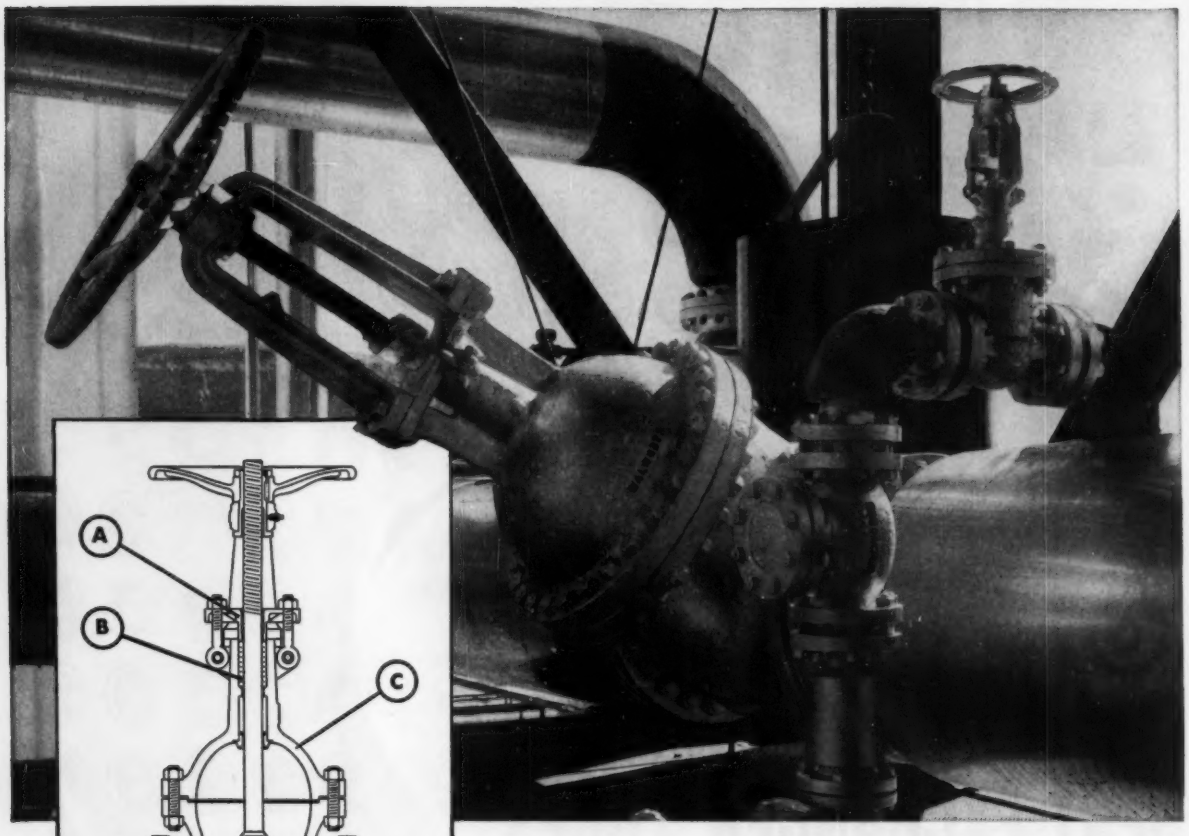
WATERBURY 20, CONNECTICUT

SUBSIDIARY OF KENNECOTT COPPER CORPORATION

The Nation's Headquarters for Brass, Copper and Stainless Steel

Atlanta Baltimore Boston Charlotte Chicago Cincinnati Cleveland Dallas Denver Detroit Grand Rapids Houston Indianapolis Kansas City, Mo. Los Angeles Milwaukee Minneapolis Newark New Orleans New York (Maspeth, L.I.) Philadelphia Pittsburgh Providence Rochester St. Louis San Francisco Seattle Waterbury

For more data on advertised products, use Readers' Service Cards, last page.



Walworth Series 150 and 300

CAST STEEL GATE VALVES OFFER YOU THESE FEATURES

for 'round-the-plant service

(A) GLANDS: Clearances between the gland and stuffing box, and gland and stem, are such that the stem cannot be scored even if the gland is pulled down unevenly.

(B) DEEP STUFFING BOXES: More than adequate in all sizes (2″ to 24″) to assure tightness and maximum packing life.

(C) BONNETS AND BODIES: Engineered to exceed the requirements of all applicable codes and standards. They are tough, durable, dependable.

(D) INTEGRAL GUIDE RIB FACES IN BODY: Machined to insure accurate centering of the gate.

(E) STURDY SEAT RINGS: Bottom-seated so that no recess exists at the back of the ring to cause turbulence, erosion and pressure drop.

(F) STREAMLINED PORTS: Permit unobstructed flow which results in minimum pressure drop and reduces the possibility of erosion.

Walworth Cast Steel Gate Valves can be furnished with either flanged ends or butt welding ends. Roller bearing yokes are available on the larger sizes. On valves 4 inches and larger, by-passes can be furnished. Walworth Cast Steel Gate, Globe and Check Valves from Series 150 to 2500, are available. For Series 600 and higher, we recommend Walworth Pressure Seal Cast Steel Valves. See your Walworth Distributor or write to Walworth for complete information.

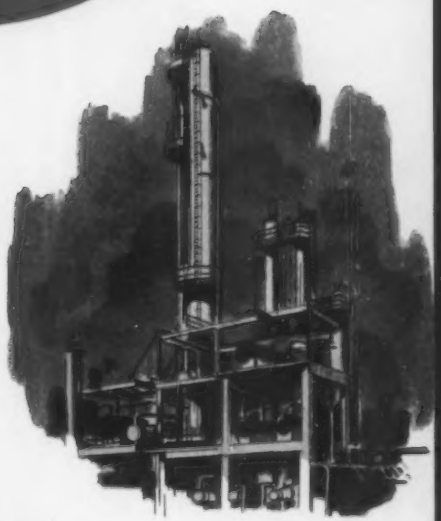
WALWORTH

60 East 42nd Street, New York 17, New York

SUBSIDIARIES: ALOYCO ALLOY STEEL PRODUCTS CO. CONOFLOW CORPORATION M&H M & H VALVE & FITTINGS CO.
SW SOUTHWEST FABRICATING & WELDING CO., INC. WALWORTH COMPANY OF CANADA, LTD.

Consistency is TRADITIONAL at WESTERN

Consistency is vital to HF ALKYLATION



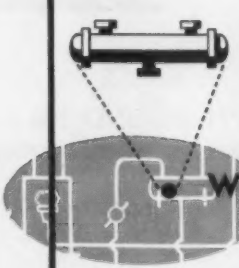
In this commercial use of hydrofluoric acid as a catalyst for the alkylation of olefins with isobutane, *consistent high quality of product* is of paramount importance in this well-established process.

HF Alkylation for the production of high octane motor fuel blending components demands *equal consistency* in the performance of the heat transfer equipment used to cool the reacting streams.

Western Heat Exchangers are characterized by consistency throughout their design and manufacture—from initial rating to completed fabrication.

Whatever the heat transfer requirement of your process, a proposal from Western should be your first consideration.

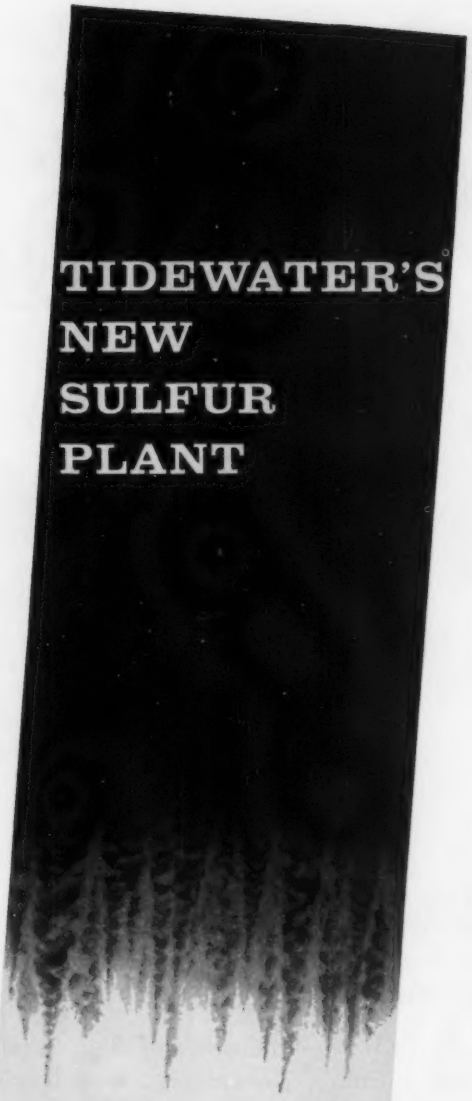
Water cooling of reacting streams is being efficiently handled by Western exchangers in many HF Alkylation units currently in operation.
There is a Western representative ready to serve you—**today.**



WESTERN
HEAT EXCHANGERS
WESTERN SUPPLY COMPANY
P.O. Box 1888 – Tulsa, Oklahoma

America's Largest

TIDEWATER'S NEW SULFUR PLANT



The H_2S Sulfur Recovery Unit at Tidewater's Refinery, near Delaware City, is one of 37 by Parsons. It is the first ever designed to operate from one-quarter to full capacity.

Parsons is proud to have had a part in Tidewater's Refinery–which is capable of handling the widest range of crudes–the largest ever built at one time.

PARSONS

THE RALPH M. PARSONS COMPANY

NEW YORK
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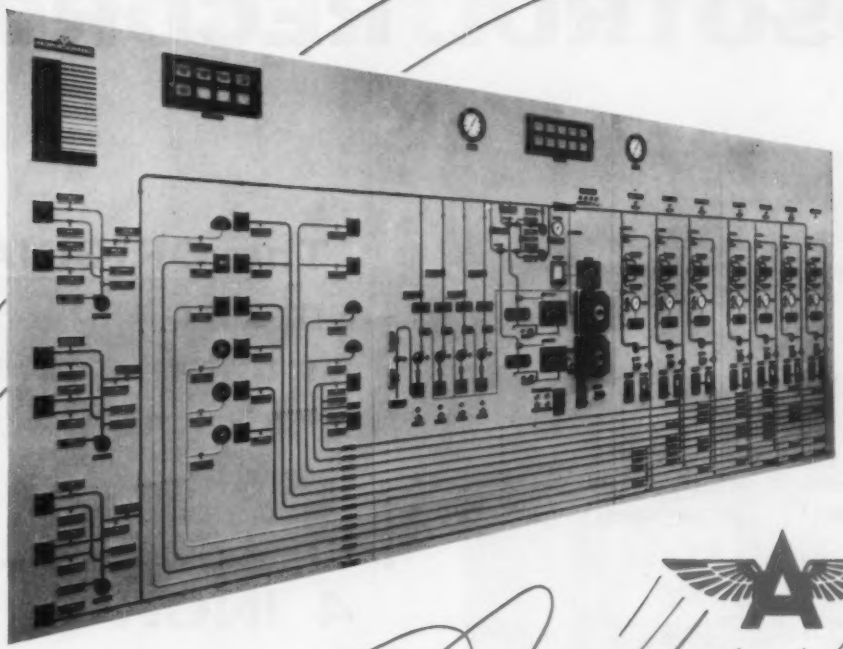


OFF TO A *Flying Start*

with *AUTOMATIC STREAM BLENDING*

of Gasolines and Distillate Fuels...

Tidewater Oil Company's new Delaware Refinery (considered to be the world's most modern refinery) utilizes the distinct competitive advantages of a Proportioneers ON-STREAM Blending System to gain maximum operating flexibility with minimum tankage outlay. Continuous automatic blending gives them more accurate product formulation at reduced cost, and . . .

- Offers blending accuracy to within a fraction of a per cent of original specification
- Minimizes intermediate tankage, in-process stocks, and blending time requirements
- Offers tailor-made hydrocarbon blends at the twist of a dial
- Offers flexibility that produces any gasoline specification at a moment's notice
- Assures "fail-safe" operation under all conditions

PROPORTIONEERS
DIVISION OF
B-I-F INDUSTRIES
METERS FEEDERS CONTROLS

Keep pace with progress by requesting complete data on this continuous automatic blending system. Write **Proportioneers, Inc., 412 Harris Avenue, Providence 1, Rhode Island.**

For more data on advertised products, use Readers' Service Cards, last page.

CONSOTROL* RECORDING

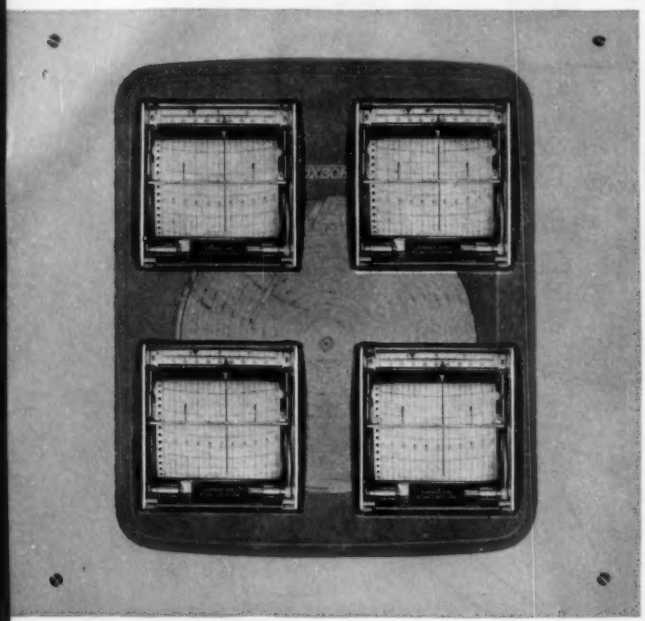


Illustration shows how 4 Consotrol Instruments require less panel space than does a single, conventional 12" recorder.

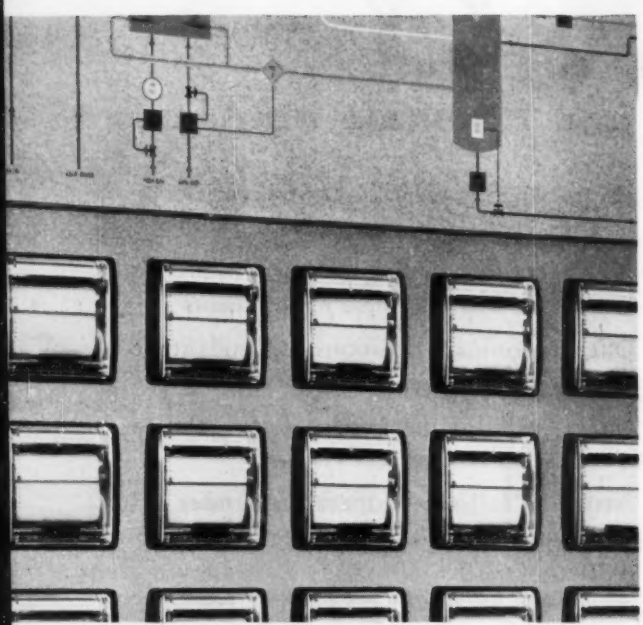
The ORIGINAL small-case control panel instrument with a FULL SCALE 4 INCH CHART...

Full-scale *readability!* Here is the industry standard set by Consotrol Instruments, with no compromise in compactness, convenience, or performance.

These Recorders and Recording Control Stations are so compact you can actually mount 4 in the space required by 1 standard 12-inch recorder. And yet, inside the case, all components are full size — nothing is "miniature."

With the integrally mounted Model 58 Controller, the Foxboro Consotrol Recording Control Station provides precise, dependable control and full-scale chart records in one-quarter the panel space. Maintenance is easier too, with all calibration adjustments made from the front . . . re-inking needed only twice a year . . . chart changes as seldom as once a month.

For the complete story, write for Bulletin 13-18. **The Foxboro Company, 746 Neponset Avenue, Foxboro, Massachusetts, U.S.A.**



Typical control panel showing Consotrol Recording Control Stations. Associated M/58 Controllers, integrally mounted, pull out with the recorders.

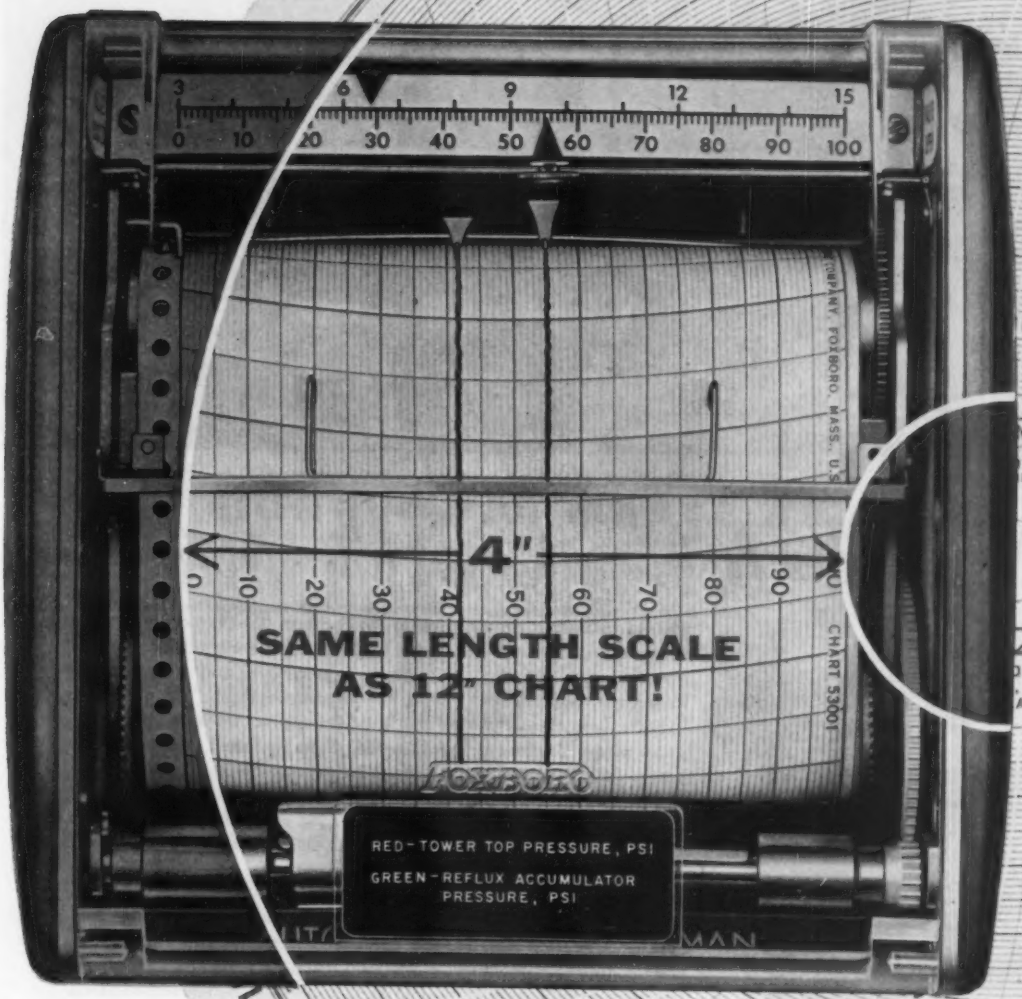
INTRODUCED IN 1952 — OVER 25,000 NOW IN USE

*Reg. U.S. Pat. Off.

FOXBORO

REG. U.S. PAT. OFF.

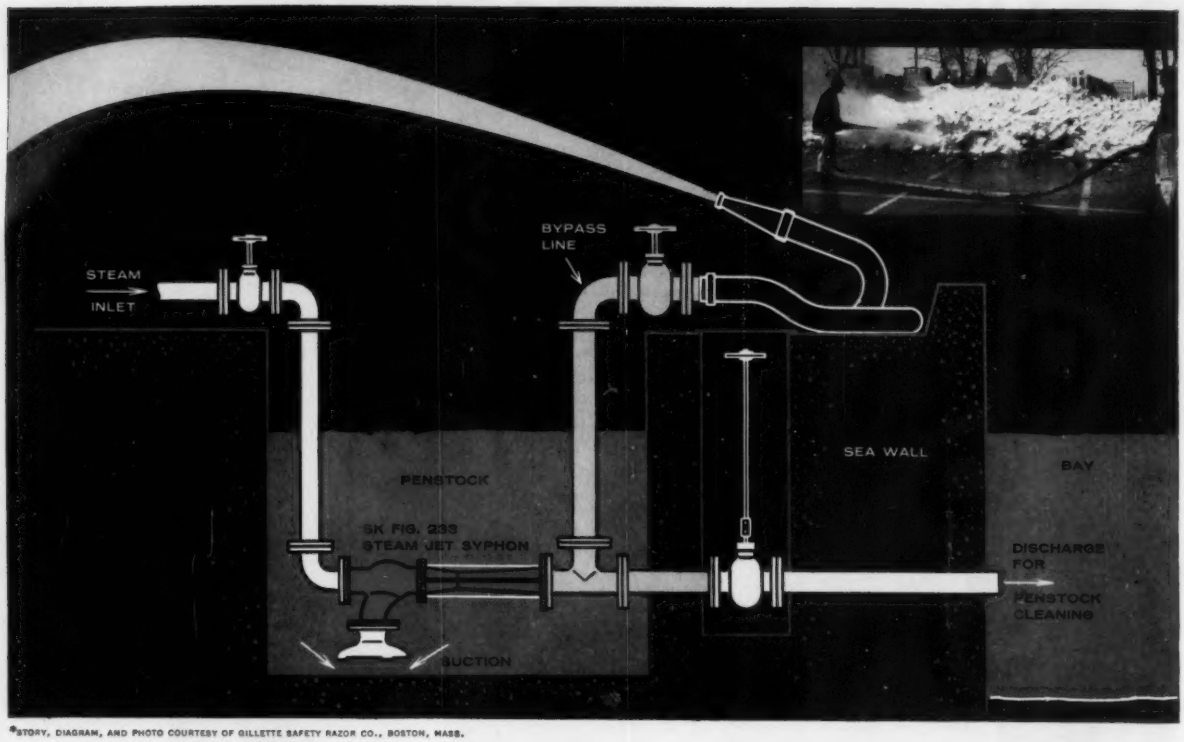
CONTROL STATION



ACTUAL SIZE illustration of Consotrol Instrument super-imposed on standard 12-inch chart. Note full 4" wide strip chart has same length scale as 12" circular chart.

CONSOTROL INSTRUMENTS

RECORDING · CONTROLLING · INDICATING



*STORY, DIAGRAM, AND PHOTO COURTESY OF GILLETTE SAFETY RAZOR CO., BOSTON, MASS.

THIS SK STEAM JET SYPHON
performs dual function at great saving

SK Steam Jet Syphon provides hot water for melting, removing snow. Syphons in large sizes, 4 in. (250 gpm) to 10 in. (3000 gpm) are widely used for emergency drainage. Small sizes, ½ in. (6 gpm) to 6 in. (600 gpm) are used for intermittent-but-frequent service.

Before installing the SK Steam Jet Syphon illustrated above, the manufacturer who devised this system* used contractors to clean accumulated silt from a plant-area penstock and used heavy, expensive machinery to clear snow from company parking lots.

Seeking a means to do both jobs themselves at less cost, company power engineers investigated, then installed, the SK 5 in. Steam Jet Syphon shown above. To clean the penstock, the bypass line valve is closed and the discharge-to-bay and steam valves are opened. Pressure steam, issuing from the syphon nozzle, entrains water and silt from the penstock and discharges, against a head, into the bay.

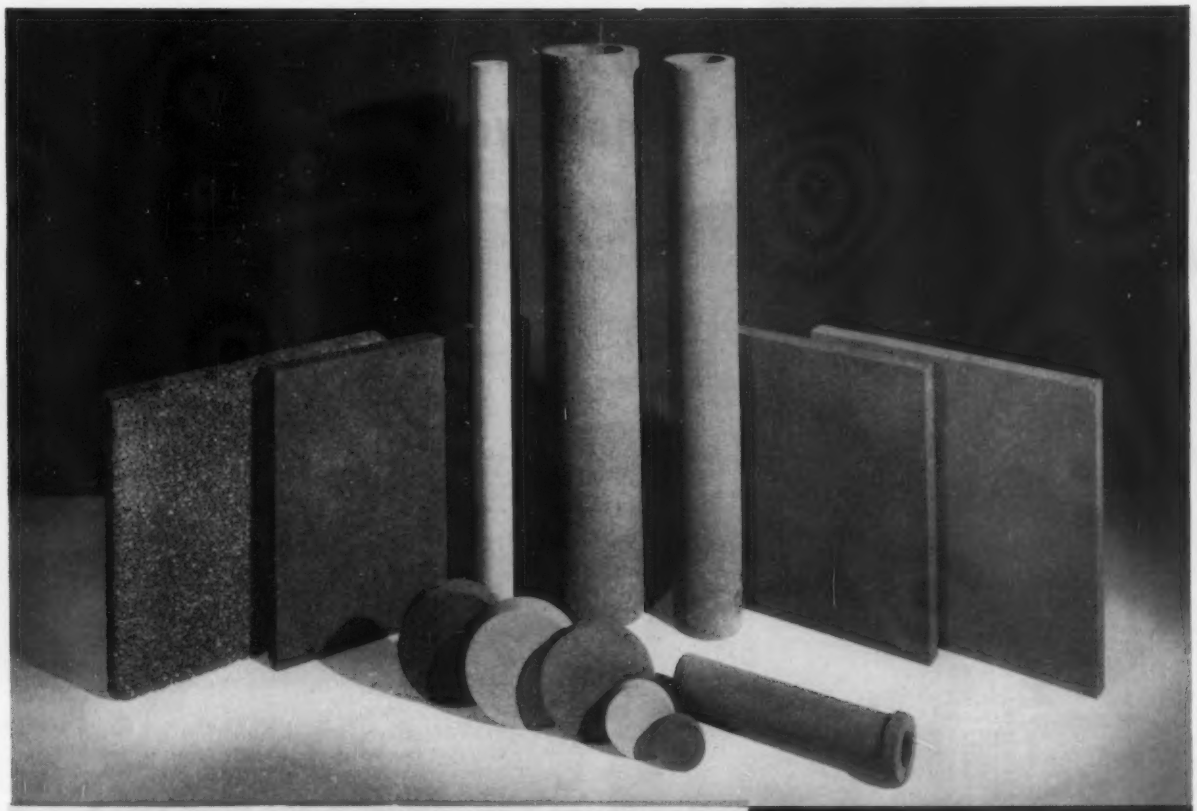
For clearing snow, as much as 500 ft. of 3 in. fire hose is attached to the bypass line. The bay line valve is closed and the bypass and steam valves are opened. The pressure steam entrains water from the penstock and discharges through the hose. The hot water from the hose, at 500 gpm, is used to melt and wash the snow into catch basins, see photo.

The syphon cost about $500.00. It now costs about $120.00 to clean the penstock (a substantial saving) and the cost of removing snow is about one-tenth of the previous cost.

Imaginatively applied, SK Jet Apparatus can do many jobs well at low cost. Learn more about Jet Apparatus by writing for Bulletin J-1 which describes SK's complete line and many applications.

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin 10-RA.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin 17-A.

Schutte and Koerting
COMPANY
MANUFACTURING ENGINEERS SINCE 1876
2257 State Road, Cornwells Heights, Bucks County, Pa.



Norton ALUNDUM porous tubes and plates made by a controlled structure process. Available in a range of sizes and degrees of permeability for filtration, aeration and diffusion.

Leaders choose Norton porous media

Foremost filter manufacturers find ALUNDUM products pay off*

Such leading manufacturers of filter equipment as Proportioneers, Inc. of Providence, Rhode Island, use ALUNDUM porous tubes in their equipment. Made of tough aluminum oxide, these acid-resistant tubes can really take it — that's why they provide long, trouble-free service.

For Your Processing

Specify ALUNDUM porous media — tubes and plates — *engineered and prescribed* to give you better service, save your time and cut costs. Contact your local Norton Representative or write direct for descriptive literature to NORTON COMPANY, Refractories Division, 465 New Bond Street, Worcester 6, Massachusetts.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

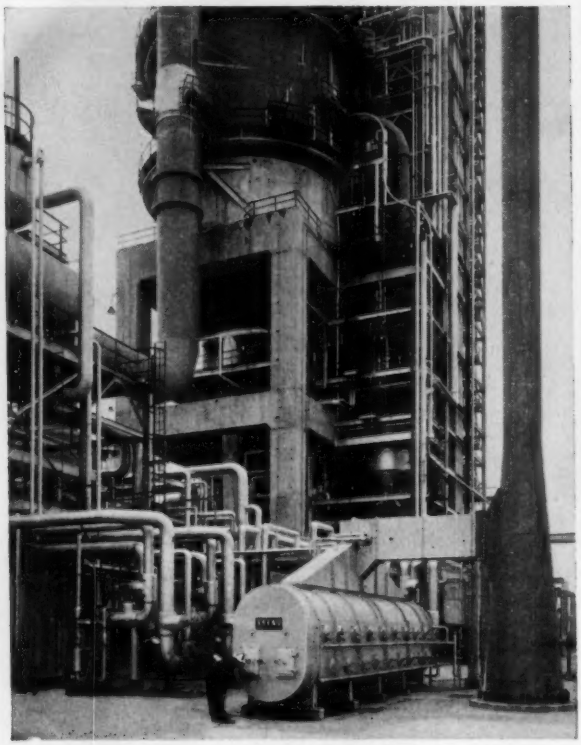
ALUNDUM *seamless* porous tubes are ideal for diatomite filters producing clear, clean water for swimming pools, municipal water systems and industrial use.

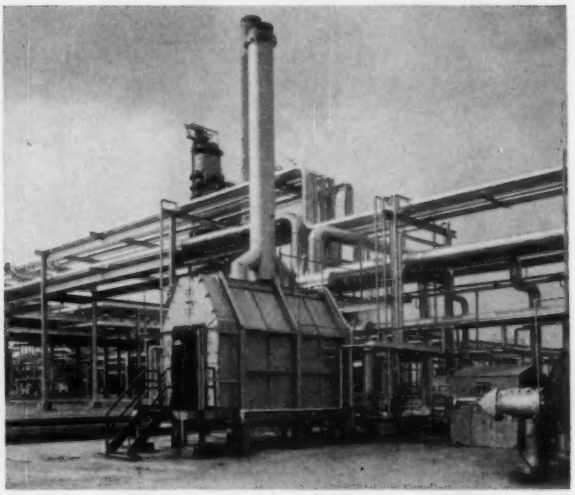
NORTON
REFRACTORIES
Engineered... Rx ...Prescribed
Making better products . . . to make your products better

NORTON PRODUCTS:
Refractories • Abrasives • Grinding Wheels • Grinding Machines
BEHR-MANNING DIVISION:
Coated Abrasives • Sharpening Stones • Behr-cat Tapes

For more data on advertised products, use Readers' Service Cards, last page.

GRADIATION® and ECONOTHERM*... Selas Heaters designed and built to meet your processing needs





The Gradiation barrel-type heater (left) superheats steam in two precisely-controlled stages of Tidewater's continuous coking process. The Econotherm heater (above), designed and built to serve low cost requirements where precision heating is not a consideration, maintains asphalt in fluid form for easier handling.

. . . perform critical and non-critical operations at Tidewater Oil Company's ultra-modern Delaware Refinery

Selas is proud to have a part in the development of Tidewater Oil Company's new Delaware plant, the largest refinery ever built at one time. Here, where initial capacity is 130,000 b/d:

- Gradiation heating meets critical processing requirements
- Econotherm heating serves non-critical demands

Each heater is designed and built to perform its specific function.

When the petroleum, petrochemical and chemical industries require preciseness in heating, ability to handle a variety of feed stocks, instant response to controller demand, Zone Control . . . they specify Gradiation. When heating is to be performed below the decomposition point of the material, when low first cost is the important factor . . . they choose Econotherm. Both are Selas heaters; both bring to each process Selas knowledge, skill, experience and service.

Write Dept. 146 for bulletin "Gradiation Heating for Petroleum and Chemical Processing."

* Trade Name

SELAS CORPORATION OF AMERICA DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers

DEVELOPMENT • DESIGN • CONSTRUCTION

Think you'll ever need
A-power fittings like these?

TUBE-TURN* Stainless Steel Elbows—heavy wall thickness for nuclear energy reactor.

Name your piping problem...
TUBE TURNS CAN HELP YOU!

No matter what kind of welded piping system you build . . . here's how Tube Turns can be of help:

Tube Turns' line includes 12,000 *standard* welding fittings and flanges, plus thousands of *specials* such as the A-power fittings shown above. When you buy from this *complete-line* leader, you get what you need *promptly* . . . products of unsurpassed *quality* . . . backed by experienced *engineering service* . . . for reliable, *low-cost piping*. Order from your nearby Tube Turns' Distributor.

*"TUBE-TURN" and "tt" Reg. U.S. Pat. Off.

The Leading Manufacturer of Welding Fittings and Flanges

TUBE TURNS LOUISVILLE 1, KENTUCKY

A Division of National Cylinder Gas Company

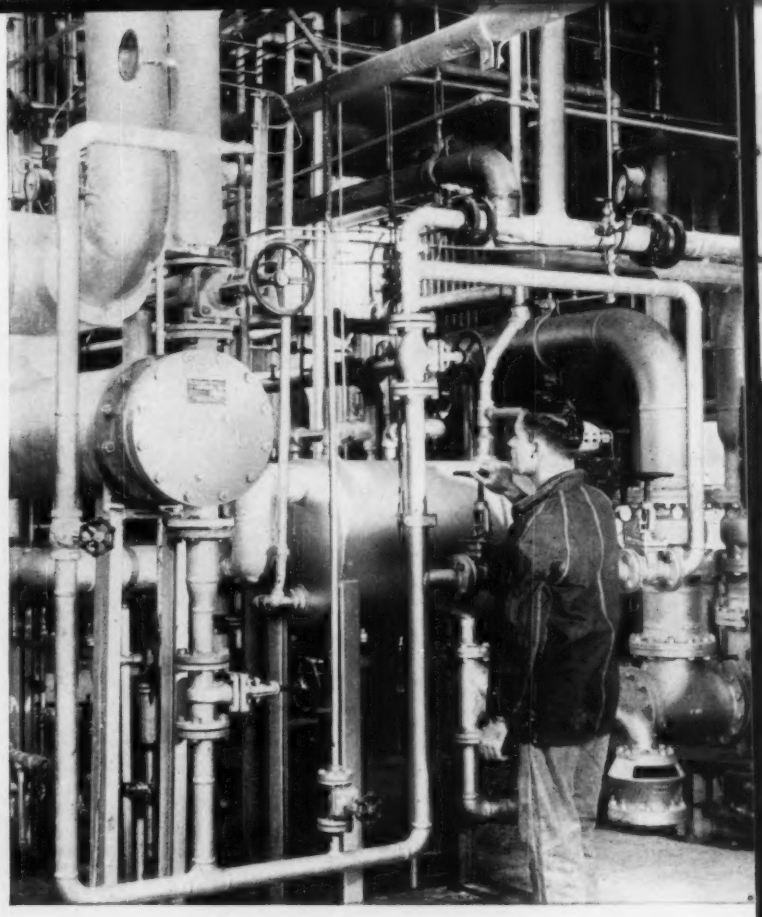
DISTRICT OFFICES: New York • Philadelphia • Pittsburgh • Chicago • Detroit • Atlanta • New Orleans • Houston • Midland Dallas • Tulsa • Kansas City • Denver • Los Angeles • San Francisco • Seattle

In Canada: Tube Turns of Canada, Ltd., Ridgetown, Ontario • Toronto, Ontario • Edmonton, Alberta

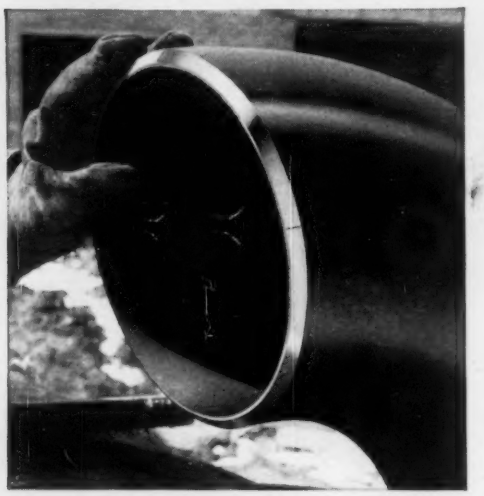
HOW YOU SAVE

12,000 "TUBE-TURN" PRODUCTS

to help you save 3 ways...



SIMPLIFIES ENGINEERING. There's no compromise when you specify TUBE-TURN products. You can count on getting the exact fittings for your project ...the right type, size, schedule and material for every piping service. Shown at right: Aluminum piping with TUBE-TURN Welding Fittings and Flanges, in water purification plant of The General Tire & Rubber Company, Chemical Division, Ashtabula, Ohio.



SPEEDS UP THE JOB. Uniform size, circularity, wall thickness of TUBE-TURN Welding Fittings assure good fit-up and alignment . . . help make piping installation work faster. Each fitting is marked with *complete* specifications for quick, accurate identification. Quartermarked bevels simplify fabrication.

ONE-ORDER PURCHASING. Your nearby Tube Turns' Distributor provides this complete-line service promptly. Hence, you can make *one order* fill all your needs in welding fittings and flanges . . . to cut red tape and save purchasing time.

HELPFUL DATA. New Tube Turns' booklet gives information on pipe, fitting and flange materials. Mail coupon for your free copy.

TUBE TURNS, Dept. Y-3
224 East Broadway, Louisville 1, Kentucky

Please send free copy of Pipe, Fitting and Flange Materials.

Company Name _____

Company Address _____

City _____ *Zone* ____ *State* _____

Your Name _____

Position _____

Available from your nearby TUBE TURNS' distributor

*"TUBE-TURN" and "tt" Reg. U. S. Pat. Off.

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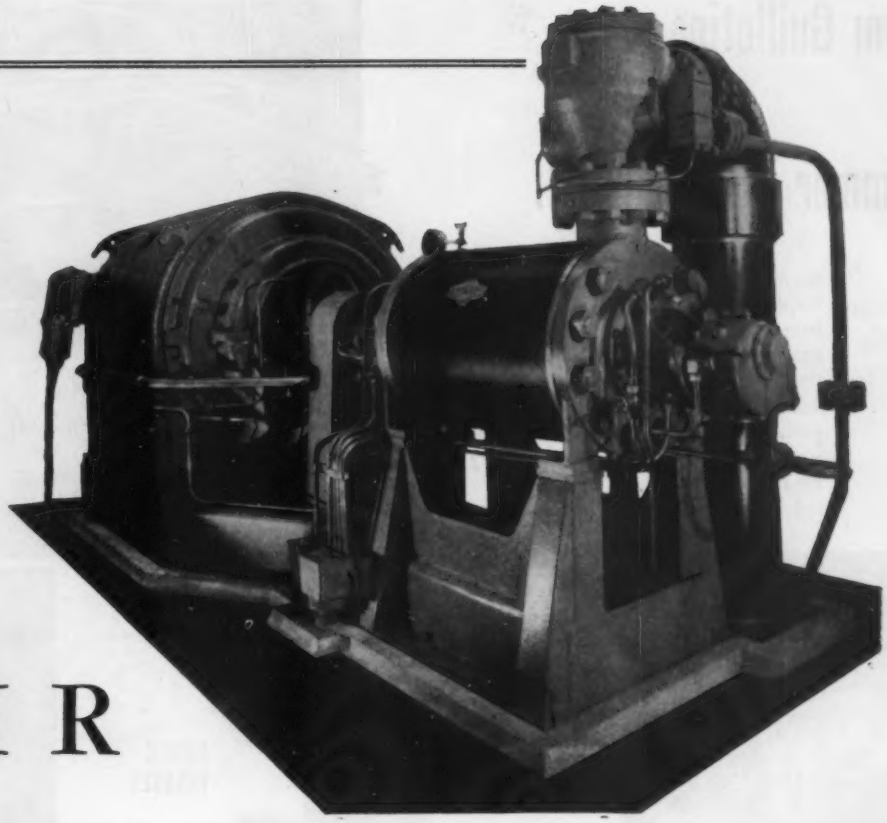
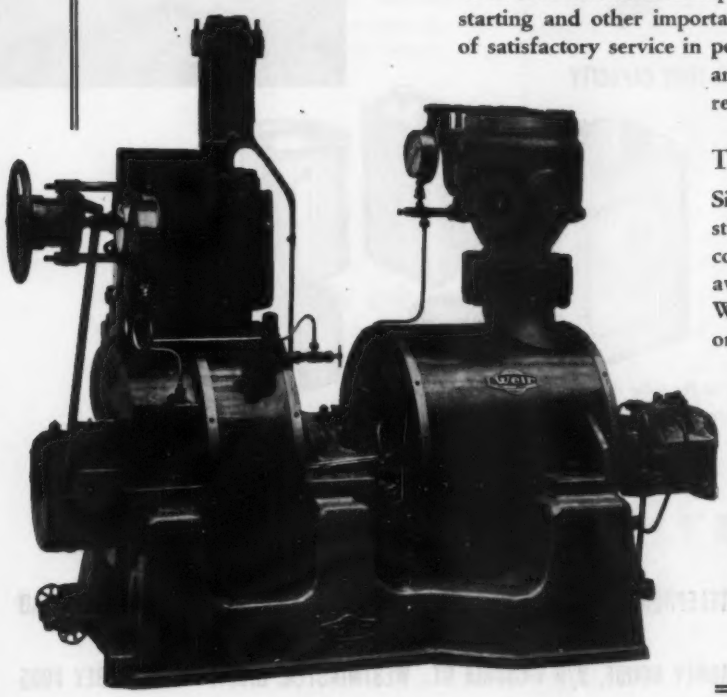
A DIVISION OF NATIONAL CYLINDER GAS COMPANY

DISTRICT OFFICES: New York • Philadelphia • Pittsburgh • Chicago Detroit • Atlanta • New Orleans • Houston • Dallas • Midland Tulsa • Kansas City • Denver • Los Angeles • San Francisco • Seattle
In Canada: **Tube Turns of Canada Limited, Ridgetown, Ontario Toronto, Ontario • Edmonton, Alberta**



WEIR

BOILER FEED PUMPS



ELECTRICALLY DRIVEN

Weir Electrofeeders incorporating patented by-pass, patented automatic starting and other important technical features have given many years of satisfactory service in power stations employing the highest pressures and temperatures, where they operate with reliability and high efficiency.

TURBINE DRIVEN

Single and multi-stage pumps supplied in standard sizes and capacities, or to meet specified conditions. Exhaust steam is free from oil and available for process work or for feed heating. Weir multi-stage pumps are made in ring section or barrel casing types.

Write for Publication No. OM.35
"Feeding the Modern Boiler"

G. & J. WEIR LTD
CATHCART GLASGOW

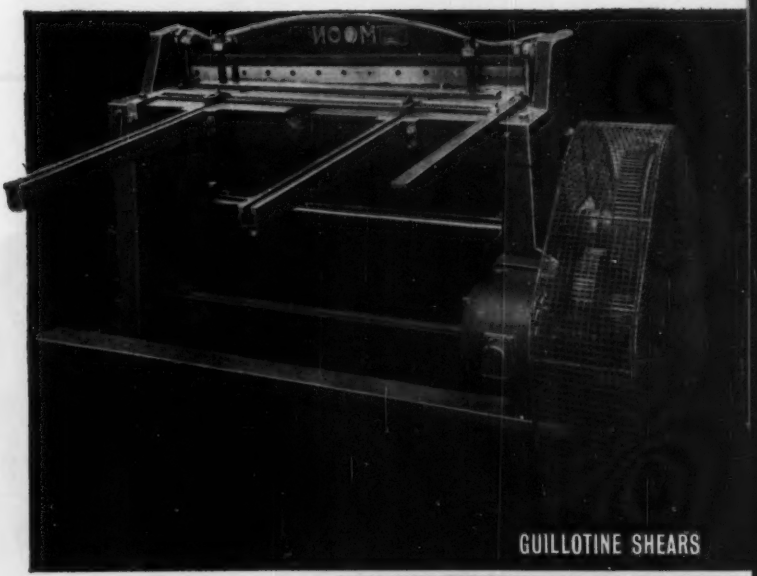
SCOTLAND

For more data on advertised products, use Readers' Service Cards, last page.

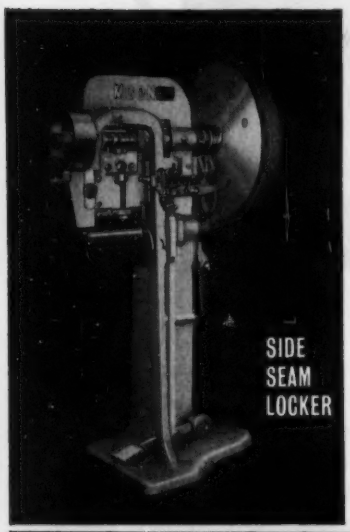
From Guillotine to Trimmer and Beader...

we make the whole range of machines for the manufacture of round and irregular tins of all sizes; for example, ham tins, paint tins, biscuit tins, oil tins, etc.

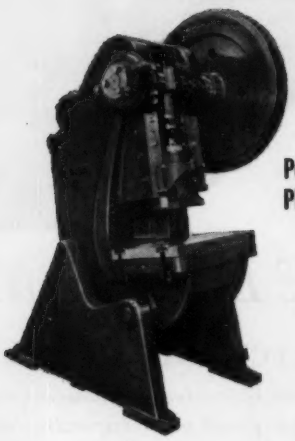
For many years we have supplied complete plants, comprising hand operated, semi-automatic and fully-automatic machinery for all sizes of tin boxes, steel drums and screw caps.



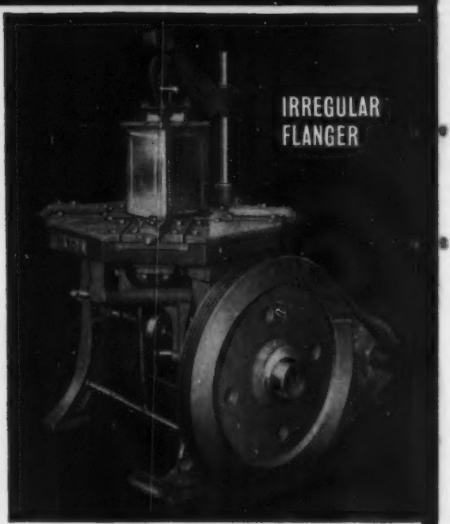
GUILLOTINE SHEARS



SIDE SEAM LOCKER

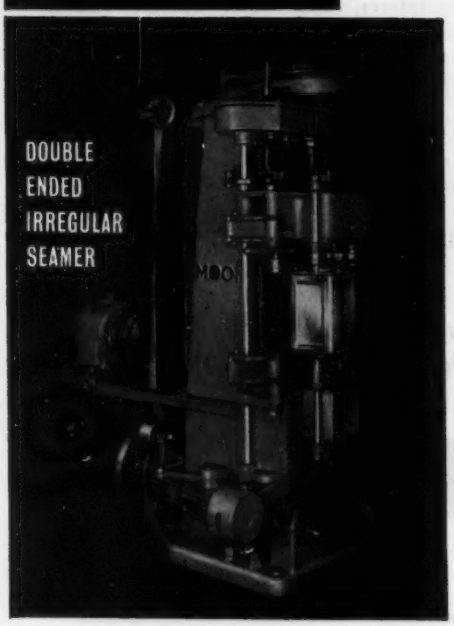


POWER PRESSES

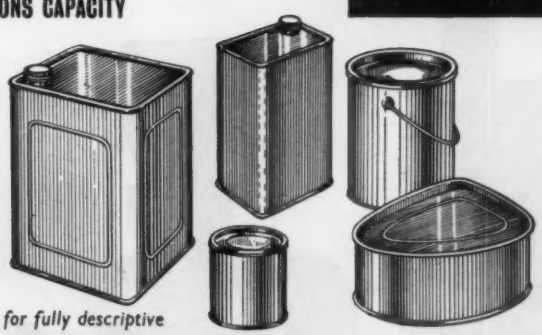


IRREGULAR FLANGER

6-60 TONS CAPACITY



DOUBLE ENDED IRREGULAR SEAMER

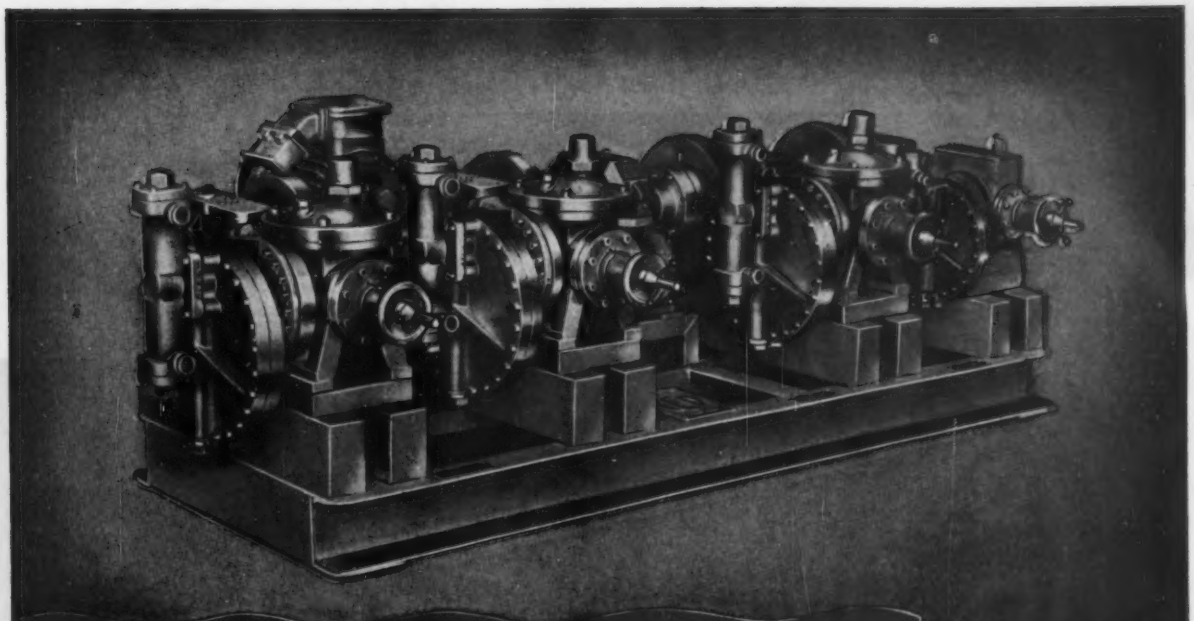


Write for fully descriptive literature to:—

MOON

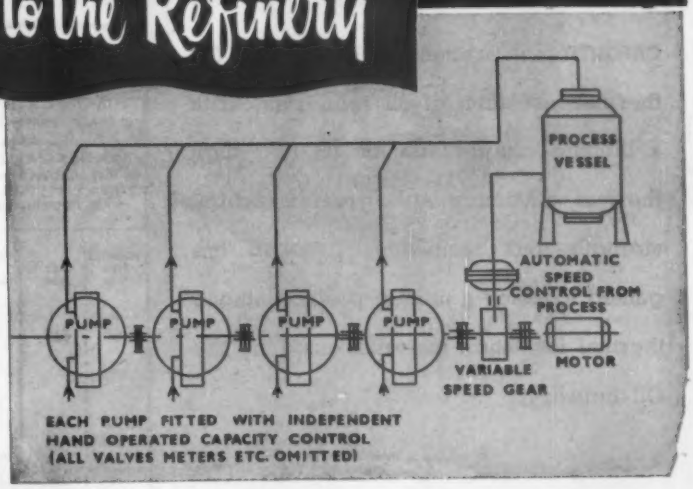
MOON BROTHERS LIMITED, BEAUFORT ROAD, BIRKENHEAD.
TELEPHONE: BIRKENHEAD 1527/8/9. CABLES: "MOONBRO" BIRKENHEAD

LONDON OFFICE
ABBEY HOUSE, 2/8 VICTORIA ST., WESTMINSTER, S.W.1. TEL: ABBEY 1905



Automation comes to the Refinery

The above photograph illustrates an assembly of four hydraulically operated piston diaphragm pumps of various capacities, each fitted with micro capacity control.



The pumps are driven by one motor through a variable speed hydraulic gear box fitted with standard pneumatic diaphragm head connected to the control so that the speed of the complete unit can be varied from zero to full by a signal pressure from 3 to 15lb. per square inch. This in conjuction with the individual capacity control on each pump enables the rate of delivery of any mixture to be automatically controlled from the process plant.

E.C.D. LTD TONBRIDGE · KENT

E.C.D. LIMITED · ENGINEERS

TONBRIDGE · KENT · ENGLAND

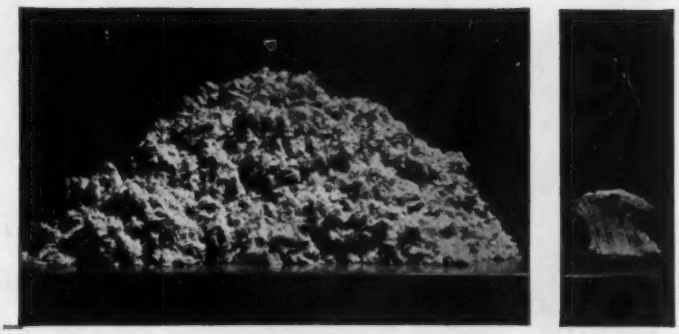
Telephone : Tonbridge 2237 (3 lines)

Telegrams : Tonmil, Tonbridge.

For more data on advertised products, use Readers' Service Cards, last page.

Refinery Insulation

All CAPOSITE moulded insulation materials are made of Amosite asbestos. The photograph clearly demonstrates the immense volume which is obtained when the natural Amosite is fiberised—the sign of high efficiency as an insulating medium.



CAPOSITE is supremely well suited to the thermal insulation of oil refineries. With a limiting temperature of 1000°F., high thermal efficiency and great structural strength and resilience, CAPOSITE has gained for itself a unique position among thermal insulation materials used by the Oil Industry.

CAPOSITE MOULDED ASBESTOS FIBRE PIPE INSULATION

EFFICIENCY DATA SHEET—PIPE SIZES 6" to 10" BORE.

HOT FACE TEMPERATURE °F.			400°F			600°F			800°F		
THERMAL CONDUCTIVITY K=B.Th.U. in./sq. ft./hr./in./°F.			0.43			0.47			0.53		
MEAN TEMPERATURE °F.			250			350			450		
Nominal Pipe Size	O.D. pipe	Thickness of Insulation	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.
6"	6⅝"	1"	135	87·7	126	233	90·6	167	354	92·5	218
		1½"	102	90·8	107	177	92·9	135	270	94·3	171
		2"	83·6	92·4	97	145	94·1	118	223	95·3	145
		2½"	71·8	93·5	91	125	95·0	107	192	96·0	128
		3"	63·5	94·2	86	110	95·5	100	170	96·4	117
		3½"	57·3	94·8	83	100	96·0	95	154	96·7	109
		4"	52·6	95·2	81	91·7	96·3	91	142	97·0	103
8"	8⅝"	1"	130	88·0	127	225	90·8	169	341	92·7	222
		1½"	97·7	91·0	108	169	93·1	137	258	94·5	174
		2"	79·2	92·7	98	138	94·4	120	211	95·5	148
		2½"	67·4	93·8	92	117	95·2	109	180	96·1	131
		3"	59·2	94·6	87	103	95·8	102	159	96·6	120
		3½"	53·2	95·1	84	92·7	96·2	96	143	96·9	111
		4"	48·5	95·6	82	84·6	96·5	92	131	97·2	105

These figures are compiled from results of official tests by THE NATIONAL PHYSICAL LABORATORY, TEDDINGTON, computed in accordance with formulae shown in BRITISH STANDARD SPECIFICATION appendices.

Please write for full technical details

THE CAPE ASBESTOS COMPANY LIMITED

114 & 116 Park Street, London, W.1.

Cables: Incorrupt, London.

CAPOSITE REGD

Amosite Asbestos Blocks and Pipe Sections

Enquiries in CANADA to: Cape Asbestos (Canada) Ltd., 200 Bloor Street East, Toronto, Ont.
U.S.A.: The North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois.
SOUTH AFRICA: Cape Asbestos South Africa (Pty.) Ltd., P. O. Box 2533, Johannesburg; ITALY: Capamianto S.P.A., via Sant' Antonino 57, Turin. FRANCE: Isolamiante S.A. 37 Avenue Franklin D. Roosevelt, Paris 8e.

CAPE

When piping changes direction, protect process equipment with

ZALLEA SELF EQUALIZING UNIVERSAL EXPANSION JOINTS

Zallea Self Equalizing Universal Expansion Joints absorb any movement in any direction . . . axially, laterally, angularly, or any combination of these . . . making them ideal for protecting process vessels and rotating equipment from thermal expansion of connected piping.

When there is a leg or 90° offset to a long run of pipe, one Zallea Universal Expansion Joint will frequently take care of the entire system.

Under conditions of low load requirement for anchors or equipment . . . or when compressive loading in pipe walls must be kept to a minimum . . . Zallea Universal Expansion Joints are the most economical answer to the problem. They absorb the internal pressure thrust. The piping system need only carry the relatively small deflection loads.

Many types of Zallea Tied Expansion Joints are designed especially to absorb lateral deflection or rotation when there is pressure in the line. Universal, Modified Universal, Hinged, Gimbal, Pressure Balanced and Universal Pressure Balanced Expansion Joints give you a choice of the type best suited to your particular application.

Get the complete story of Zallea Expansion Joints in our new 72-page manual. Write, on your company letterhead, for your copy of Catalog 56. Zallea Brothers, 890 Locust Street, Wilmington 99, Delaware.

Zallea
expansion joints

Zallea Brothers • Wilmington 99, Delaware

World's largest manufacturer of expansion joints

24" dia. Zallea Universal Self Equalizing Expansion Joints in service lines of the engine test facility of a West Coast aircraft manufacturer.

WHEN YOU SPECIFY "FLEXITALLIC"

There is something unique about Flexitallic Spiral-Wound Gaskets, the result of more than 45 years in gasket design and construction. At Flexitallic . . .

Compression response of the gasket is directly related to bolting for each application;

With the desired gasket design determined, exacting mechanical controls assure that manufactured gaskets conform to specification.

That is why more and more engineers insist on *Flexitallic* Spiral-Wound.

Flexitallic Gaskets are designed to meet specific conditions of pressure, temperature, thermal shock, chemical attack and cyclic operation. Spiral-Wound V-crimped plies of required metal with alternating plies of proper filler result in a gasket with compression characteristics like those of a precalibrated spring.

Flexitallic Gaskets — for pressure/temperature ranges from vacuum to 10,000 lbs. from sub-zero to 2000° F. For all standard joint assemblies.

FLEXITALLIC GASKET CO.
8th & Bailey Sts., Camden 2, N.J.
Representatives in principal cities

Flexitallic®
SPIRAL-WOUND GASKETS

FOR PIPE FLANGES, PRESSURE VESSELS AND PROCESS EQUIPMENT

*Flexitallic is a registered trade name. No one else can make a Flexitallic Gasket. Look for *Flexitallic Blue*—it's our exclusive blue-dyed Canadian asbestos filler.

For more data on advertised products, use Readers' Service Cards, last page.

You Can't Find the Cost of a Valve on a Price List

With today's high maintenance expense, the cost of keeping a troublesome valve in repair can dwarf its original price in a few months' time. The minute a maintenance man touches a wrench to a valve, its cost is often doubled. That's why the purchasing trend is to *top quality* —the longest-lasting, most dependable industrial equipment on the market. And in the valve field, that means Lunkenheimer . . . famous for quality and maintenance-free service since 1862. The Lunkenheimer Company, Box 360 Annex Station, Cincinnati 14, Ohio.

The cost of a Lunkenheimer Valve gets smaller...and smaller...and smaller... with each passing year of dependable service

LQ600-150
150 lb. S. P.
300 lb. W. O. G.

LQ600-200
200 lb. S. P.
400 lb. W. O. G. 550°F.

¼ to 2 inches

WRITE FOR NEW FOLDER
"The Evidence in the Case"
Review Actual Case Histories from the Files of Industry on
HOW TO CUT MAINTENANCE

BRONZE • IRON • STEEL • PVC

E-467-17

LUNKENHEIMER QUALITY

LUNKENHEIMER
THE ONE *Great* NAME IN VALVES

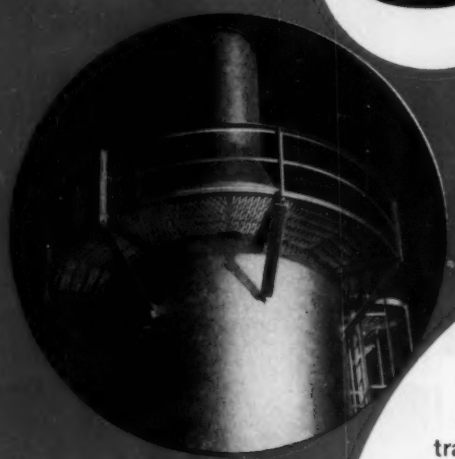
For more data on advertised products, use Readers' Service Cards, last page.

you can judge

the comparative values of furnace design as applied to operating requirements.

It's quite simple

there are **9** basic factors which must be evaluated to obtain the full comparison of values



1—Average radiant transfer rate. 2—Maximum deviation from average radiant transfer rate. 3—Average and maximum transfer rate in convection section. 4—Maximum tube wall temperature, radiant or convection. 5—Maximum efficiency with specified excess air. 6—Controlled thermal recirculation of flue gases to provide even heat distribution throughout full length of each tube and equalized heat distribution around each tube. 7—Overload and corresponding transfer load. 8—Design to provide: structural column supports - Ladders - Platforms - Tube Removal facilities, etc. 9—Degree of assembly; of the furnace structure and of the heating surface.

Whenever all these 9 specifications are applied to all the operating requirements, you can be sure PETROCHEM ISOFLOW FURNACES will be found most economically desirable.

No other furnace design can claim the recognition and acceptance achieved by PETROCHEM ISOFLOW FURNACES . . . starting with one installation in 1940, January '57 records more than 1650 ISOFLOW FURNACES in operation and under construction—a record that is incomparable just as all Petrochem Isoflow furnaces are more economically desirable by any comparison.

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 EAST 42nd St., New York 17, N. Y.

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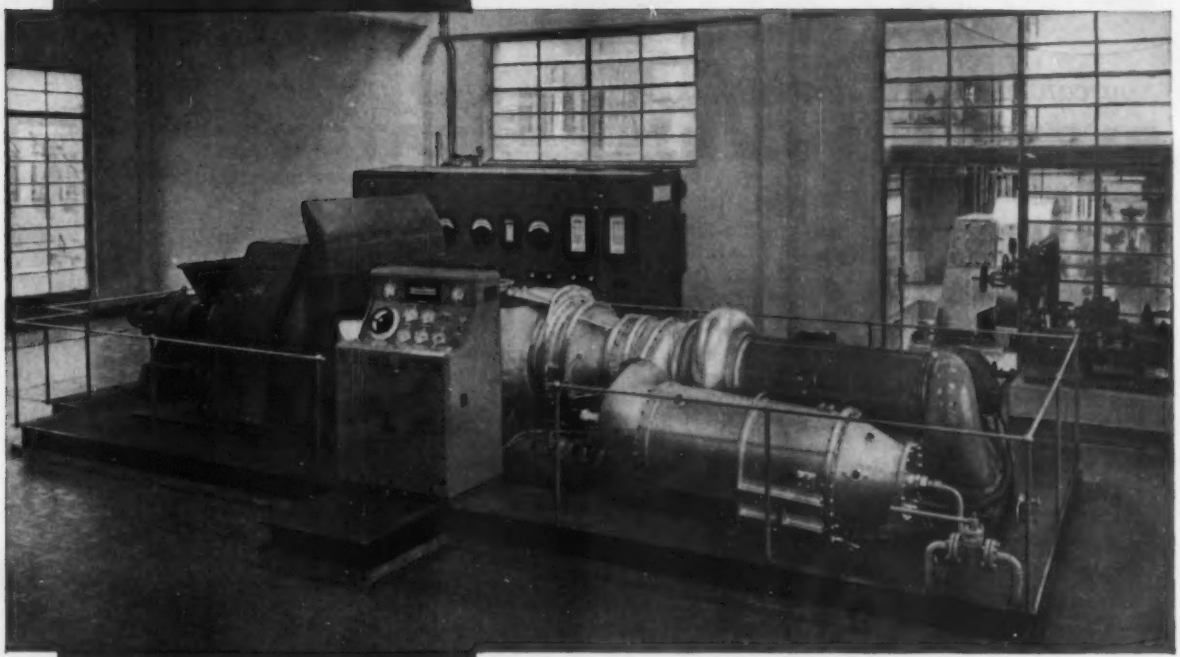

The Mark TA gas turbine generating power and process steam in a refining application.

all power services in one package

In applications where multiple power services are required such as power generation, compressing, pumping, space heating, refrigeration, air conditioning, drying, or evaporating, the Clark Mark TA gas turbine is the economical choice.

Exhaust gases from this 1,150 bhp. gas turbine contain up to 10,000,000 BTU/H of recoverable energy at a temperature of 870°F. While these gases contain some products of combustion, 90% of the original oxygen content is still present.

The exhaust gases are useful where preheated air is desirable for combustion or supercharging purposes, for drying applications, catalyst regeneration, feedwater heating, evaporation of sea water, etc. These gases can also be used in air to air heat exchangers for space heating or to generate up to 9,500 pounds of low pressure steam per hour for process use. If even higher temperature gases are required, the Mark TA can be used solely as a power gas generator to provide gases of 1020°F at 20-22 psia. and a mass flow of 20 pounds per second.

For large stores, auditoriums, hotels, hospitals and office buildings, the Mark TA can provide approximately 1800 tons of air conditioning or refrigeration in the summer using the absorption cycle and also provide steam for heating in the winter. In all applications except power gas generating, this modern gas turbine also supplies 1,150 bhp. of rotative energy for pump, generator, or compressor drive.

Clark engineers stand ready to assist you in applying the Mark TA gas turbine to your application. Larger units with ratings of 9,500 bhp. are also available from Clark. Write for Bulletin No. 142.

CLARK BROS. CO., OLEAN, N.Y.
One of the Dresser Industries
Offices in Principal Cities Throughout the World

Clark Bros. Co. is licensed to manufacture the Mark TA gas turbine in this country by Ruston-Hornsby, Ltd., Lincoln, England.

CLARK

For more data on advertised products, use Readers' Service Cards, last page.

you can meet any lubrication specification if you

BLEND WITH ENJAY PARATONE®

(VISCOSITY-INDEX IMPROVERS)

Base stocks blended with Enjay Paratone can be compounded into lubricants combining cold-weather quick starting properties with high temperature, low consumption characteristics. These lubricants are *all-season* oils, featuring improved gas mileage. More and more refiners and blenders are relying exclusively on Paratone to produce the high "VI" required in these all-season oils.

Through years of intensive research and development work with automotive manufacturers, Enjay has developed the only *complete line* of high quality additives (Paramins®) that can assure *maximum* performance characteristics. Why not let this experience and know-how work for *you*? Write, wire or phone the Enjay Company.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 WEST 51st ST., NEW YORK 19, N. Y.

Akron • Boston • Chicago • Los Angeles • New Orleans • Tulsa

COMPARATIVE RESULTS OF DRYING AIR

Test	Relative Positions in Series of Dehydrating Agents During Test*	Gain in Weight Grams	Moisture Adsorbed % of Total
A	1st—Activated Alumina	0.0778	99.9
	2nd—Calcium chloride	—0.001	— 0.1
	3rd—Sulfuric acid	±0.0000	0.0
	4th—Phosphorus pentoxide	0.0002	0.2
B	1st—Phosphorus pentoxide	0.0764	97.8
	2nd—Calcium chloride	0.0001	0.1
	3rd—Sulfuric acid	0.0002	0.3
	4th—Activated Alumina	0.0014	1.8
C	1st—Sulfuric acid	0.0853	95.2
	2nd—Activated Alumina	0.0042	4.7
	3rd—Calcium chloride	0.0001	0.1
	4th—Phosphorus pentoxide	±0.0000	0.0
D	1st—Calcium chloride	0.0698	95.1
	2nd—Sulfuric acid	0.0002	0.3
	3rd—Activated Alumina	0.0034	4.6
	4th—Phosphorus pentoxide	±0.0000	0.0
E	1st—Barium magnesium perchlorate	0.0931	90.2
	2nd—Phosphorus pentoxide	0.0054	5.6
	3rd—Activated Alumina	0.0042	4.2
F	1st—Activated Alumina	0.1061	99.0
	2nd—Barium magnesium perchlorate	—0.0017	— 1.6
	3rd—Phosphorus pentoxide	0.0032	2.6
G	1st—Phosphorus pentoxide	0.1110	94.8
	2nd—Barium magnesium perchlorate	—0.0009	— 0.8
	3rd—Activated Alumina	0.0070	6.0

*Weight of dehydrating agents employed:
Activated Alumina.....10.52 grams
Phosphorus pentoxide..... 2.50 grams
Sulfuric acid..... 7.24 grams
Calcium chloride.....10.27 grams
Barium magnesium perchlorate.....18.53 grams

This comparison test proves superior adsorptive capacity of ALCOA ACTIVATED ALUMINA

Efficiency of a drying agent can be tested by measuring how completely it removes water from a stream of air of given moisture content. The table above shows results of such a test made on a comparative basis with these desiccants: ALCOA® Activated Alumina; phosphorus pentoxide; sulfuric acid (96% C.P.); calcium chloride; and barium magnesium perchlorate.

The desiccants were placed in a series of U-tubes. High humidity atmospheric air was drawn through the tubes. This was repeated under comparable conditions for each of the arrangements of desiccants shown in the table.

Study the test results. The superior performance of ALCOA Activated Alumina is clear!

In laboratory tests . . . as in hundreds of industrial drying applications . . . ALCOA Activated Aluminas have proved to be the most reliable commercial desiccants available. They dry to dew points below minus 100°F. They are nontoxic, chemically inert to most gases and vapors, and they will not soften, swell or disintegrate when immersed in water. They keep drying costs down because they can be reactivated an almost unlimited number of times with no serious drop in adsorptive efficiency.

Whatever you dry . . . gases, liquids or vapors . . . the effective, low cost solution to your drying problems is ALCOA Activated Alumina. Get detailed information today. Write ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 717-F Alcoa Building, Pittsburgh 19, Pa.

ALCOA CHEMICALS
ALUMINUM COMPANY OF AMERICA

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

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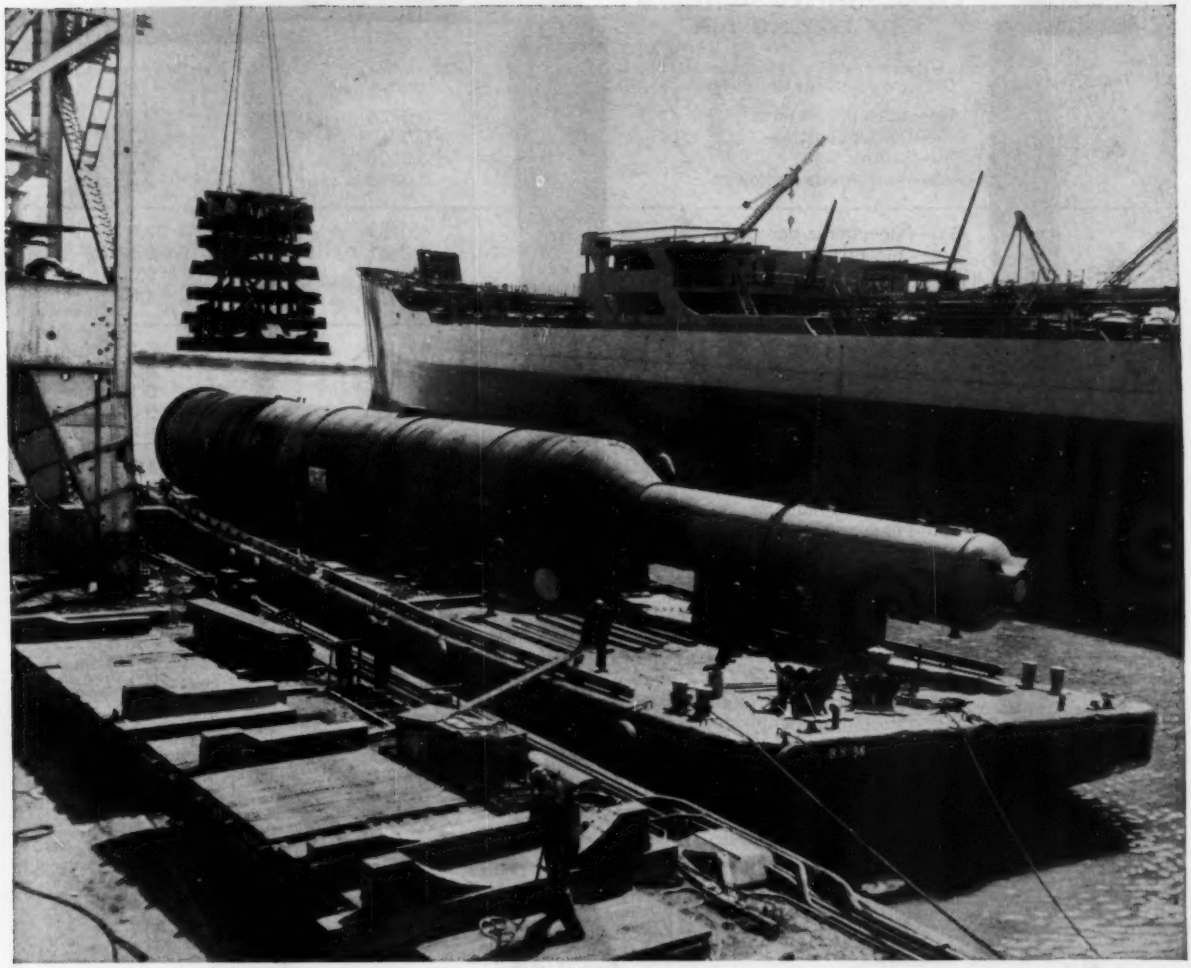


standard procedure: VERSATILITY...

The variety of work which Sun Ship's integrated shops produce for use by industries on land and sea brings a matching variety of shipping problems.

Our facilities for tidewater shipment are used to economical advantage on many of the massive structures that go into the making of the nation's petroleum and chemical industries. The barge shipment of tower and shed row baffles, shown above, is a good example.

And of course—when shipment by land is necessary—Sun Ship rigging and routing find the ways and means to handle such items as large-diameter columns by rail and truck.

It's all a part of the versatility which forty years' experience has made part of "standard procedure" in service of its customers.

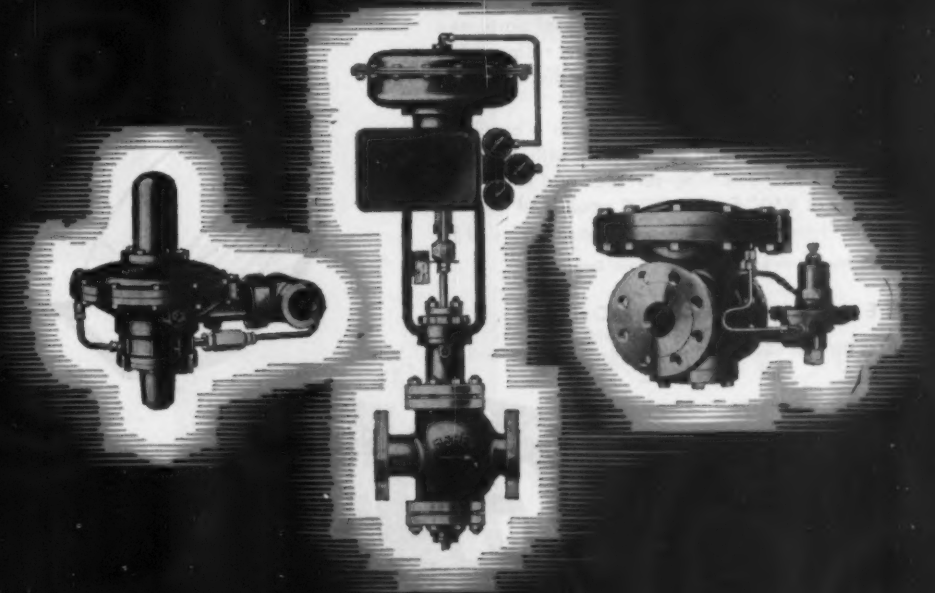
Our Sales Engineering Department would be glad to use its experience in helping you overcome any problem of construction or shipment that faces you. Write

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE SINCE 1916 **CHESTER, PA.**

the tough Control Valve jobs go to



FISHER GOVERNOR COMPANY
MARSHALLTOWN, IOWA • WOODSTOCK, ONTARIO

VOGT identification Disc...

...on top and in sight

makes it easy to identify valves — even in insulated lines

The Vogt tell-all identification disc, on every valve, is permanently located above the handwheel for complete and convenient identification. It shows valve size, catalog and drawing number, materials used for principal parts and primary pressure and temperature ratings. The flat on the handwheel protects the disc in assembly and in service.

Vogt GP Valves are available in a complete range of sizes from ¼" to 2", with HAYNES STELLITE* faced seating surfaces and rated 800 pounds at 850° F. and 2000 pounds at 100° F. (Other types are available through 8" size.)

*Trade-Mark of Union Carbide and Carbon Corporation

HENRY VOGT MACHINE CO.
P. O. BOX 1918, LOUISVILLE 1, KY.
SALES OFFICES: New York, Chicago, Cleveland, Dallas, Philadelphia, St. Louis, Charleston, W. Va.

Write For Your FREE COPY of Supplement No. 1 to Catalog F-9. Address Dept. 24A-FPR

Vogt GENERAL GP PURPOSE Vogt FOR BETTER VALVES **DROP FORGED STEEL VALVES**

Adv. No. 7 in a series describing the features of Vogt GP Valves.

Drastic reduction
of heat loss with
PABCO
PRECISION-MOLDED
CALTEMP
a Calcium Silicate
Insulation

When vapors or liquids are conveyed or held at temperatures up to 1900° F.—when equipment is operated to high heat levels—Pabco insulations cut heat losses to absolute minimums. "Precision-Molded" by a patented process, Pabco's Caltemp and 85% Magnesia pipe and block insulations control temperatures within close tolerances. For data on technical advantages, case histories, or engineering consultation, write . . or call a Pabco insulation engineer.

INSULATION GUIDE

Temperature	Recommended Pabco Insulation		
to 550°	85% Magnesia pipe covering	block	cement
to 1200°	Caltemp pipe covering	block	cement
to 1500°	Prasco 15 C pipe covering	block	cement
to 1900°	Prasco 19 C	block	

PABCO

INDUSTRIAL INSULATIONS DIVISION
Fibreboard Paper Products Corporation
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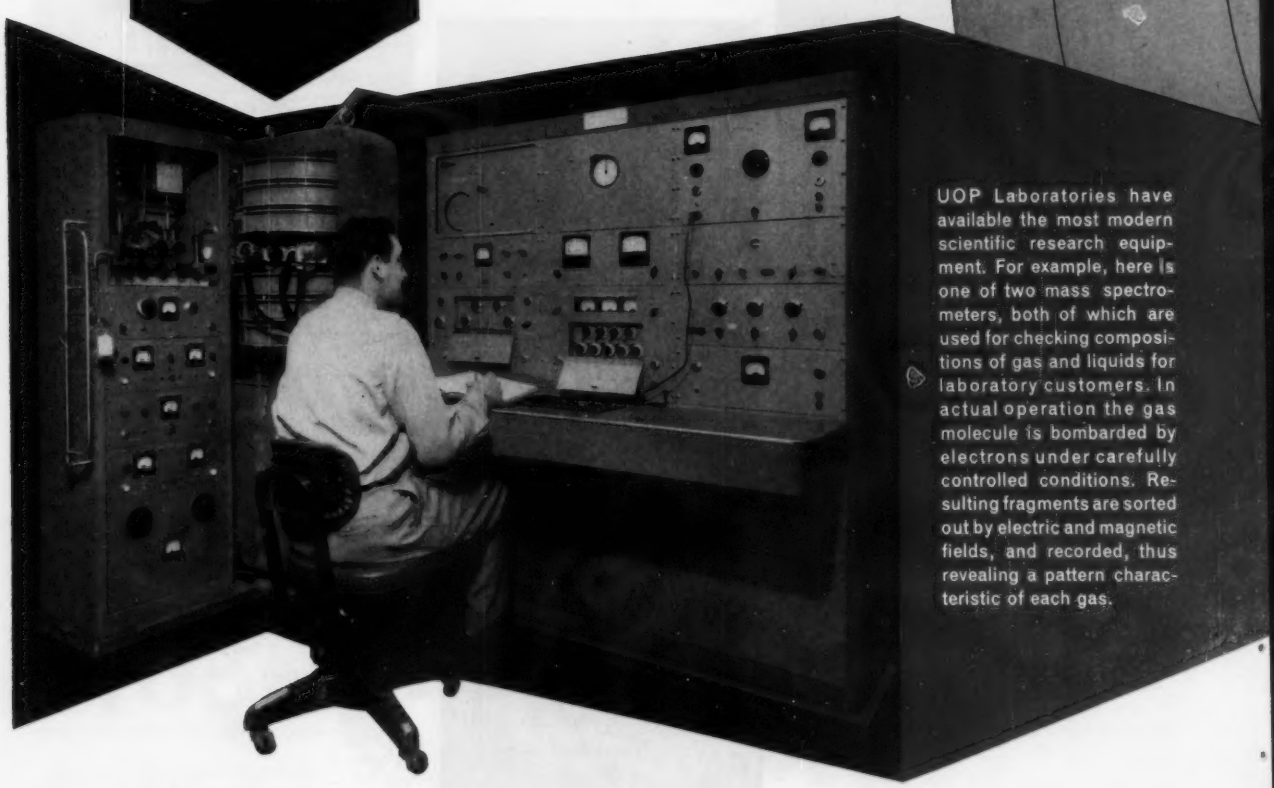
Refining and research go together. The laboratory is vital to the successful operation of any oil refinery. That's why refiners, everywhere, have come to depend on UOP for many essential laboratory functions.

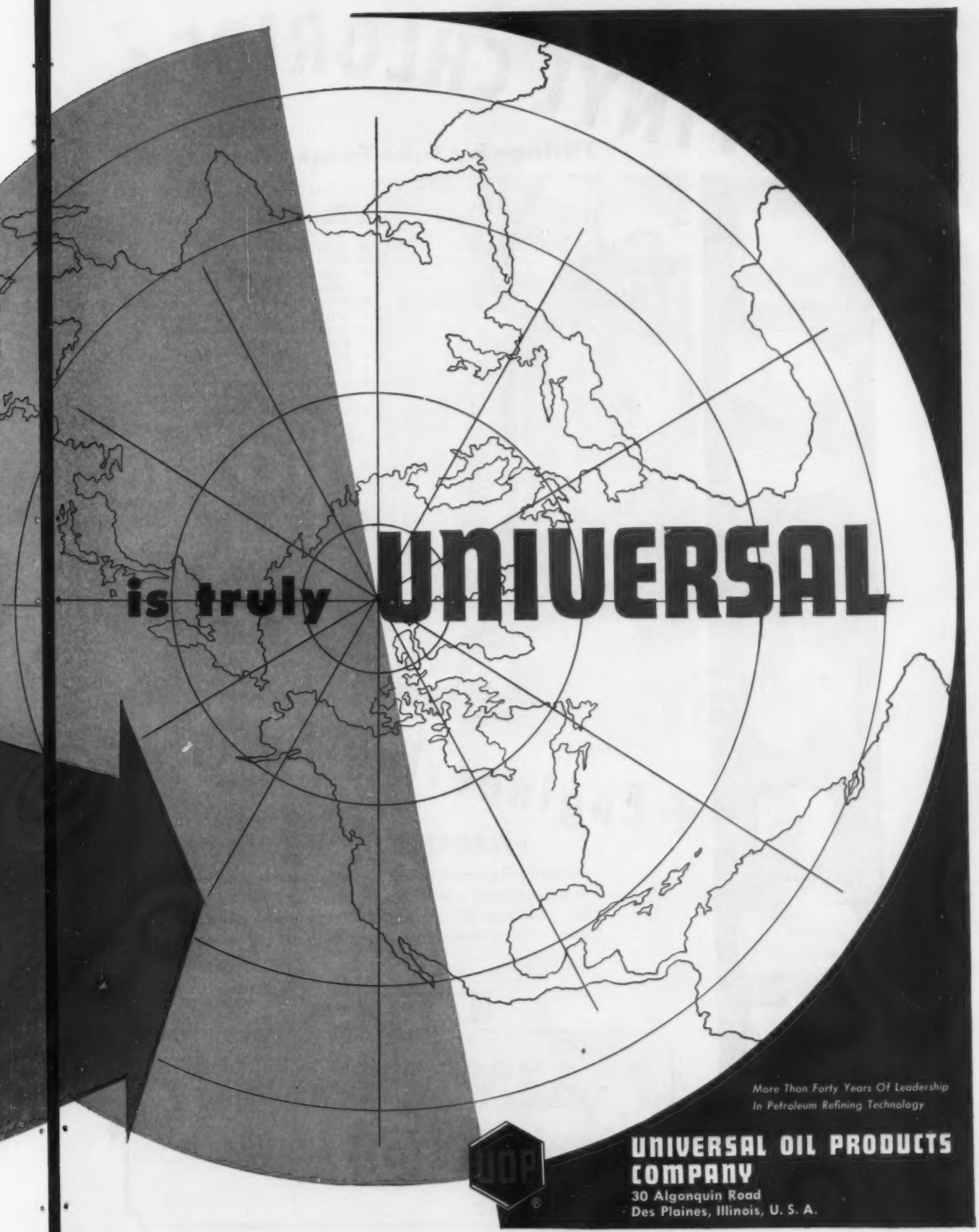
UOP laboratory service is broad, comprehensive, expert, providing vital information that in most cases would be impractical or economically impossible for the individual refiner to develop. It covers such specifics as the evaluation of crudes, problems of treating products for maximum stability, maintenance of product quality, performance of gas concentration equipment, answers all the requirements of a thorough and complete laboratory service.

Today, refiners everywhere in the free world are users of this laboratory service. It is available to any refiner, regardless of his volume or scope of operation. UOP laboratory service is truly universal.

UOP **laboratory service**



UOP Laboratories have available the most modern scientific research equipment. For example, here is one of two mass spectrometers, both of which are used for checking compositions of gas and liquids for laboratory customers. In actual operation the gas molecule is bombarded by electrons under carefully controlled conditions. Resulting fragments are sorted out by electric and magnetic fields, and recorded, thus revealing a pattern characteristic of each gas.



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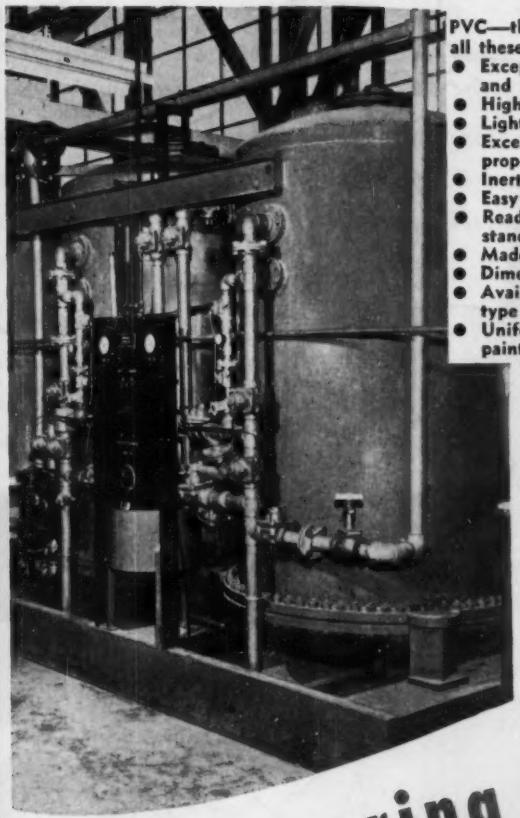
POLYVINYL CHLORIDE+*

Fittings by Tube Turns Plastics, Inc.



PVC—the new, tougher plastic with all these advantages:

- Exceptional resistance to most acids and alkalies.
- High burst strength.
- Light in weight. Non aging.
- Excellent electrical and insulating properties.
- Inert. Non-toxic. Non-flammable.
- Easy to install and disassemble.
- Ready to use. Complete with standard threading.
- Made by exclusive Hendry process.
- Dimensionally accurate, uniform.
- Available both threaded and socket type for solvent or fillet welding.
- Uniform color throughout with no painting required.

Polyvinyl Chloride Pipe:

Available in sizes ½" through 6". It does not corrode; cuts cost and practically eliminates maintenance corrosive services. Can be installed by the same method used for standard metal pipe.

+ Engineering Service!

REDUCE CORROSION!

MECO's long experience in the industrial field can help you in determining proper applications of PVC in piping systems for your operations: PVC's exceptional resistance to acids and alkalies can solve many of your corrosion problems.

WRITE OR PHONE FOR INFORMATION

MECO

MAINTENANCE *Engineering* CORPORATION

P. O. BOX 2637

3711 CLINTON DRIVE HOUSTON, TEXAS

Now-80% of all detergent oil-additives are Barium-based!

The overwhelming preference continues to grow . . . reflecting the outstanding performance of barium-based detergent oil-additives.

As the principal supplier of barium chemicals, Westvaco® developed readily soluble barium values in several forms from which these superior additives have been compounded. To keep well ahead of the demand, we have steadily increased our productive capacity and added substantially to our ample mineral reserves.

We will be glad to send you a copy of our 24-page booklet which gives complete information on Westvaco Barium Chemicals.

BARIUM OXIDE
BARIUM OCTAHYDRATE (FLAKE AND CRYSTAL)
BARIUM PENTAHYDRATE (FLAKE)
BARIUM NITRATE
BARIUM PEROXIDE
BARIUM CARBONATE
BARIUM SULFIDE

fmc® chemicals

Westvaco Mineral Products Division
FOOD MACHINERY AND CHEMICAL CORPORATION

161 E. 42nd St., New York 17 • Chicago Cincinnati Houston Philadelphia Newark, Calif.

BECCO® peroxygen chemicals • FAIRFIELD® pesticide compounds • FMC® organic chemicals • NIAGARA® insecticides, fungicides and industrial sulphur • OHIO-APEX® plasticizers and resins • WESTVACO® alkalis, solvents, phosphates, barium and magnesium chemicals

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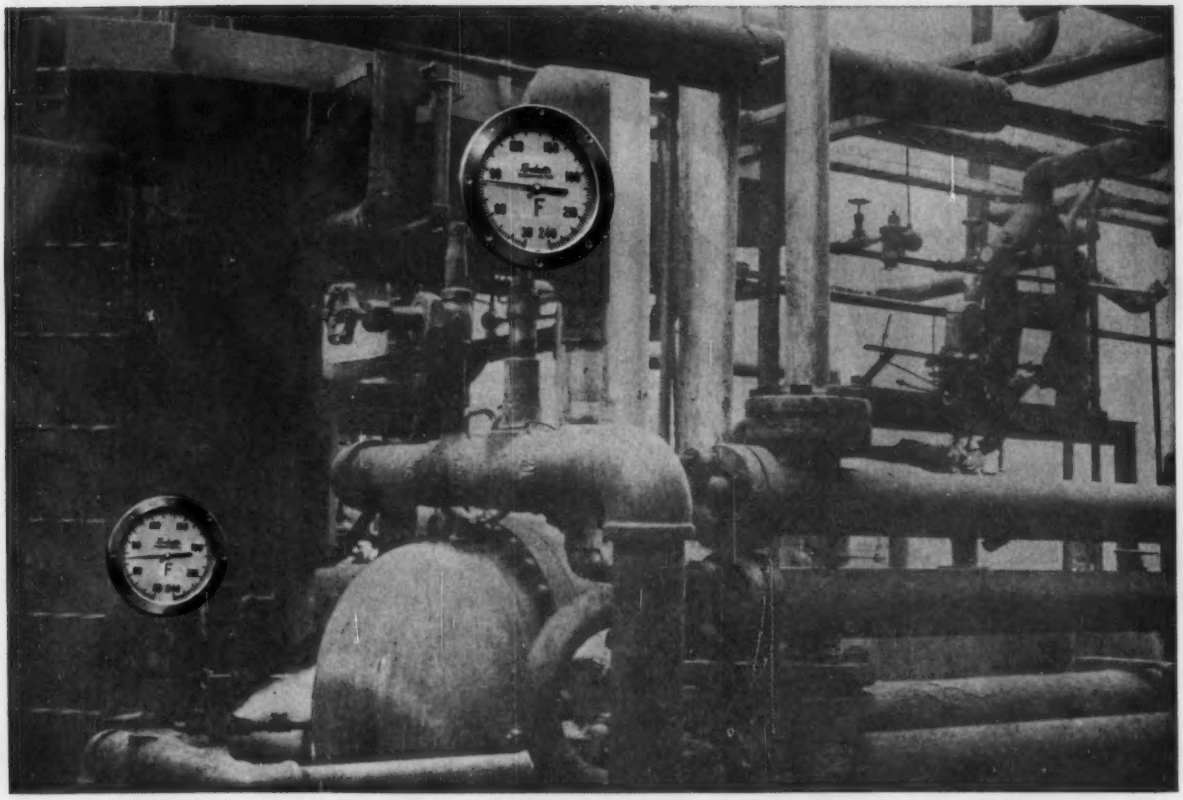

There's an RMC thermometer for almost every industrial requirement

Dial sizes from 1″ to 5″, stem lengths from 2½″ to 70″, scale ranges from −150° F to +1000° F. These figures represent *only* Rochester Manufacturing Company's *standard* thermometer specification limits. There is practically no limit to what RMC can do in the way of *special* thermometer applications.

Standard or special, *all* RMC thermometers are made of corrosive-resistant stainless steel, have hermetically sealed non-fogging dial chambers, are available with RMC's exclusive external recalibration device, and are guaranteed accurate to 1% of scale range. Why not remove temperature indication problems from your unsolved list—turn them over to RMC.

Look to RMC for Full-Line Instrumentation— for manufacturers and users of processing equipment—and many consumer products.

DIAL THERMOMETERS

PRESSURE SWITCHES

PRESSURE GAUGES

LIQUID LEVEL GAUGES

REPRESENTATIVES IN ALL PRINCIPAL CITIES

Tell us your requirements for direct mounting and remote indicating instruments, and let RMC Engineering skill provide the answers!

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LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

ROCHESTER MANUFACTURING CO., INC. • 38 Rockwood Street, Rochester 10, N. Y.

Here's Refrigeration Designed For Every Basic Oilfield Application!

...It's The New BS&B "COLD-FRAC*" Ammonia Absorption Refrigeration Unit

With the development of BS&B's new "COLD-FRAC" AMMONIA ABSORPTION REFRIGERATION Unit, the oil industry now has a simple, non-mechanical, heavy duty artificial refrigeration system which is applicable to any oilfield or refining process requiring temperatures below ordinary atmospheric level.

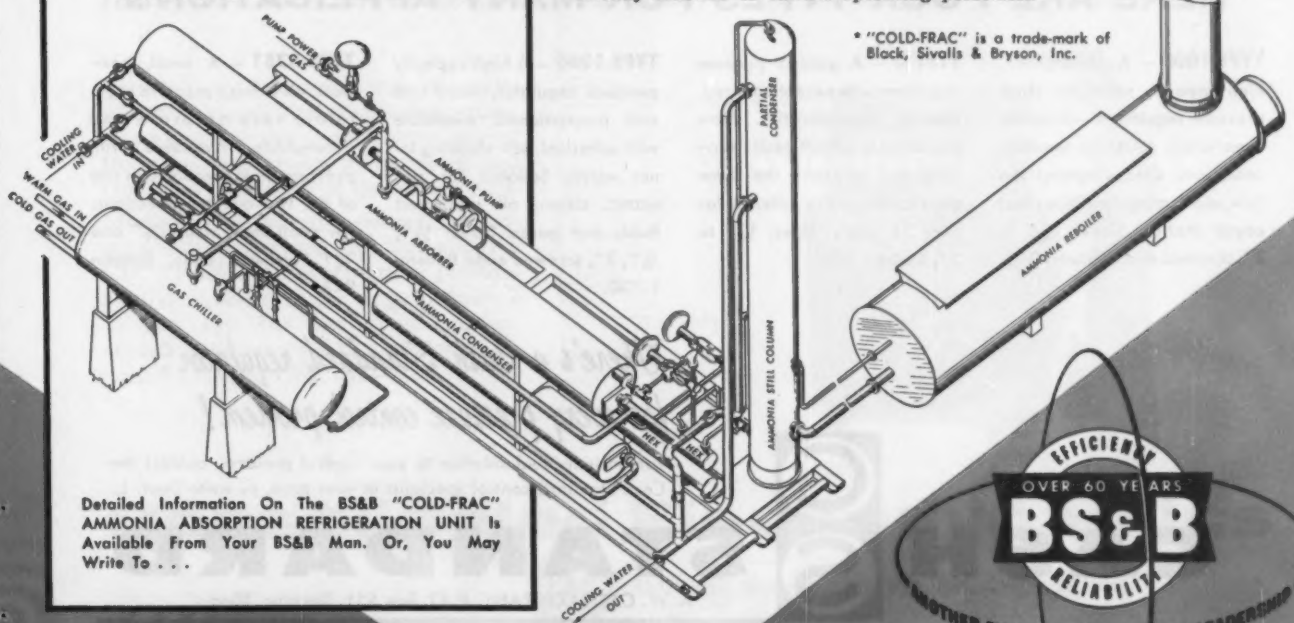
OUTSTANDING FEATURES:

1. **Entirely Self-Operating.** Automatically Adjusts to Load Changes.
2. **Low Initial Cost.** Unit May Be Skid-Mounted Except Ammonia Reboiler. Outside Construction — No Buildings Required.
3. **Low Cost Maintenance.** Liquid Pump Is The Only Moving Part.
4. **Operating Costs Vary.** In Direct Proportion To The Load.
5. **Lower Operating Temperatures** Do Not Materially Decrease Capacity.
6. **Completely Closed System.**
7. **Chiller "Slop Over" Of Liquid Refrigerant Causes No Problem.** (There is no compressor to cause worry about liquids in the suction.)
8. **Oil Lubrication Eliminated.** No Oil-Refrigerant Problem.
9. **Vibration Free.** No High Speed Reciprocating Machinery To Mount.
10. **Experts Are Not Required** To Operate and Maintain The Unit.

A few examples of immediate industry applications are:

1. **Gas Pipeline Companies — For The Elimination Of Liquids In Gas Transmission Lines Through Better Hydrocarbon Dewpoint Control.**
2. **Gasoline Plants — For The Chilling Of Absorption Oil To Increase Hydrocarbon Recoveries Without Installing Larger Absorption Oil Towers Or Pumps.**
3. **Lease Production — To Provide Essential Refrigeration For Maximum Hydrocarbon Recovery Where Sufficient Pressure Expansion Is Not Available. Also To Supplement Declining "Natural" Refrigeration.**

These Ammonia Absorption Refrigeration Units are built for rugged, heavy duty, 365 day-per-year continuous operation, and are available in eleven standard sizes. Completely automatic in operation, they are equipped with BS&B oilfield-type controls and motor valves which are already familiar to oilfield operating personnel.



* "COLD-FRAC" is a trade-mark of Black, Sivalls & Bryson, Inc.

Detailed Information On The BS&B "COLD-FRAC" AMMONIA ABSORPTION REFRIGERATION UNIT Is Available From Your BS&B Man. Or, You May Write To . . .

EFFICIENCY OVER 60 YEARS BS&B RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

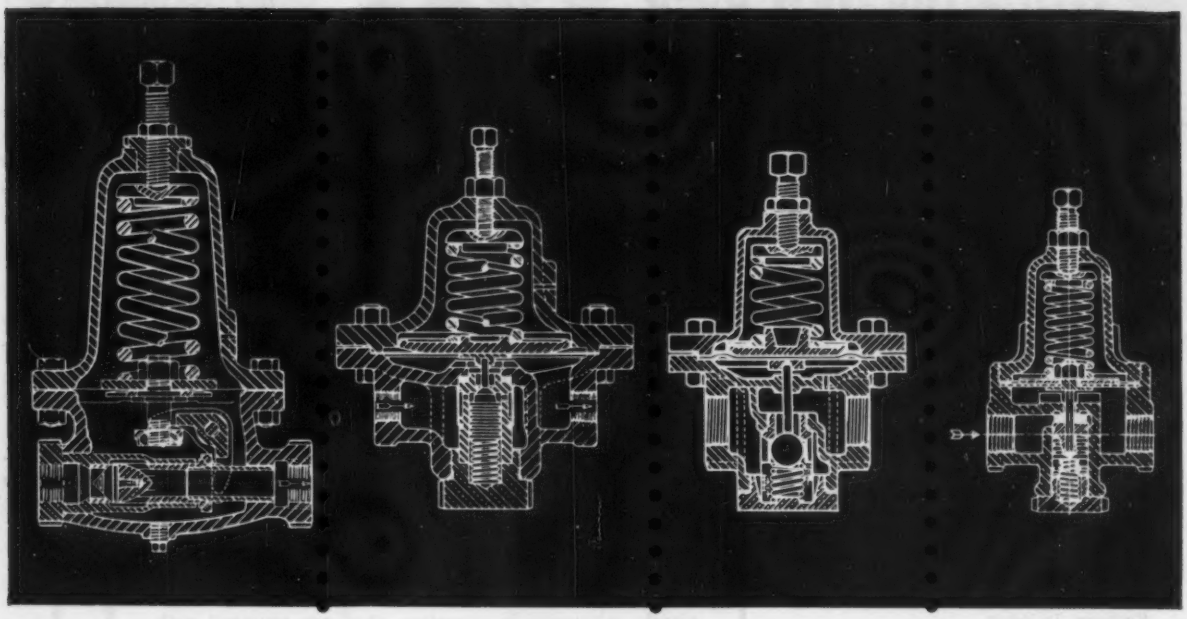
Oilfield Equipment Division, Dept. T-F6

P. O. Box 1714 Oklahoma City, Okla.

What's your pressure problem?

CASH STANDARD

has the answer... *or will find one!*



HERE ARE FOUR TYPES FOR MANY APPLICATIONS

TYPE 1000 — A streamlined, high capacity valve for close pressure regulation—accurate even under toughest working conditions. Closes against the flow, eliminating conditions that cause chatter. Sizes: ¼" to 2", screwed ends. Bulletin 962.

TYPE D — A general purpose regulator with exceptional regulation characteristics. Now improved to permit easier servicing but basically the same dependable valve offered for over 35 years. Sizes: ¼" to 2". Bulletin 950.

TYPE 1260 — A high capacity pressure regulator, small and well proportioned. Available with spherical, self-cleaning inner valve. Suitable for air, water, steam, oil and most fluids and gases. Sizes: ½", ¾", 1", screwed ends. Bulletin S-700.

TYPE 3381 — A small, compact, all-bronze pressure regulator, very accurate and dependable. Available with pressure gauge mounted in one of the two outlet connections. For small lines. Sizes: ¼" and ⅜", screwed ends. Bulletin 948.

There's a Cash Standard regulator for every pressure control problem!

For an individual solution to your control problem, contact the Cash Standard control specialist in your area, or write Dept. L.

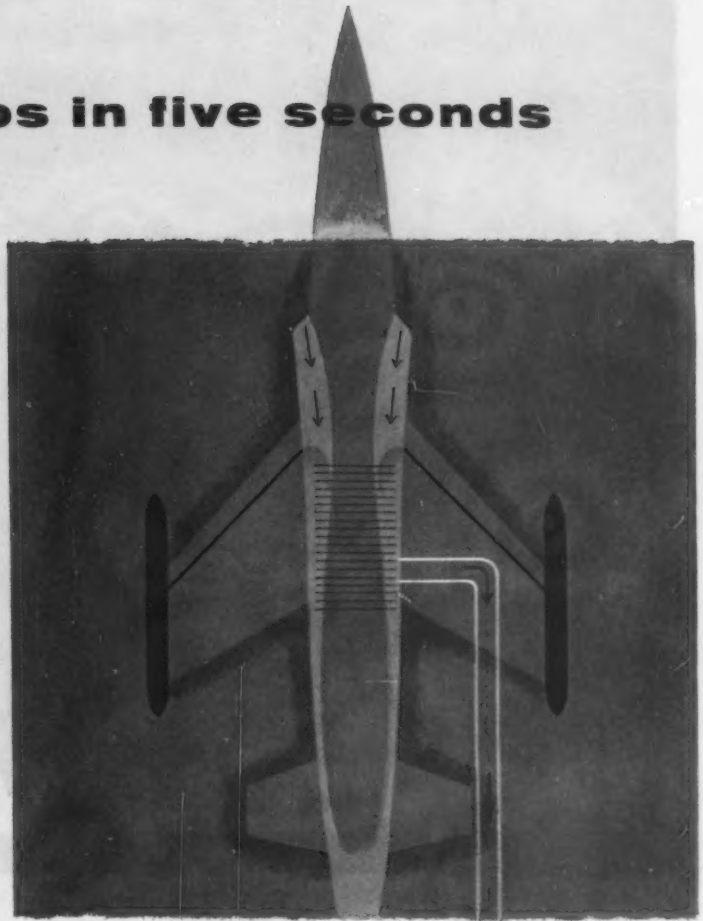
CASH C S **STANDARD**

A. W. CASH COMPANY, P. O. Box 551, Decatur, Illinois

Pressure, Hydraulic, Temperature, Process and Combustion Controls

For more data on advertised products, use Readers' Service Cards, last page.

Jet fuel/air ratios in five seconds



CEC's

MASS SPECTROMETER

helps solve long-standing

aircraft problem

How do you get rapid, accurate data on the fuel/air distribution within a jet engine? Teamed with an explosion-proof manifold which does the sampling through a probe in the burner chamber, a CEC 21-620 Mass Spectrometer provides plotted data never before obtainable so rapidly and so easily.

Gas samples reach the mass spectrometer 75 feet from the test burner in five seconds. This technique also makes it possible to follow thermal cracking and reforming of fuel components within an engine operating at extremely high temperatures.

Ideal for closed-loop process control on chemical processes

This mass spectrometer system is equally adaptable for any kind of chemical process where it is desirable to control the ratio of feed gases. It is possible to control the feed ratio, and the quality of the end-product.

Ideally suited for process-stream or atmosphere - monitoring applications, the CEC 21-620 Mass Spectrometer provides accurate readings in the range of mass 2 to mass 150. For detailed information, contact your nearby CEC field office, or write for Bulletin CEC 1824-X21.

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

...more quality proved POWELL VALVES

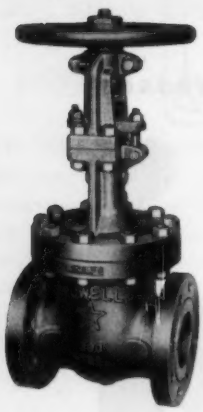


FIG. 3003—Steel Gate Valve for 300 Pounds W.S.P.

FIG. 1559—Steel Lubricated Plug Valve, ASA 150 Pounds, Screwed Gland Type, 1" to 4", inclusive.

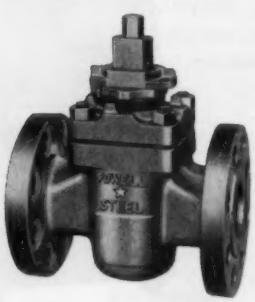
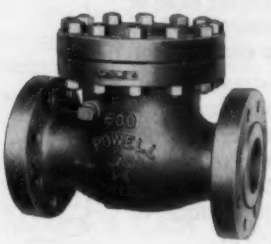


FIG. 2456 SG—Large Stainless Steel Gate Valve for 150 Pounds W.P. Flanges conform to latest Standards.

FIG. 6061—600-Pound Steel Swing Check Valve.



Designed for long life, designed for dependable service

Consult your Powell Valve distributor for all the facts about quality proved bronze, iron, steel and corrosion-resistant valves. No matter what the flow control problem, a Powell Valve can solve it . . . *better.*

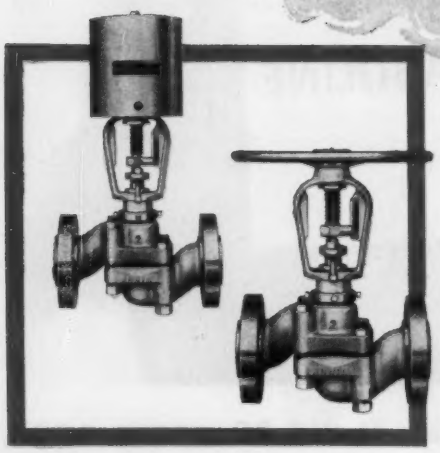
THE WM. POWELL COMPANY, CINCINNATI 22, OHIO . . . 111th YEAR

Yes, Virginia, gasoline does cost less than it did 30 years ago. (Before taxes, of course.) Most oilmen know this story; we know how the power in regular gasoline has climbed from 50 octane in the mid '20s to over 90 today. We know, too, what a fantastic value gasoline represents as a commodity. An industrial worker labored 23 minutes to buy a gallon in 1926; today he works just 6½ minutes for a better product. *We* know—but the public does not. What are *you* doing to tell them? **SHELL OIL COMPANY**

For more data on advertised products, use Readers' Service Cards, last page.

TOP HAND

...where Management
...Production and
Maintenance
are concerned!



ANNIN VALVES *meet every test of reliability, response and easy maintenance at low cost*

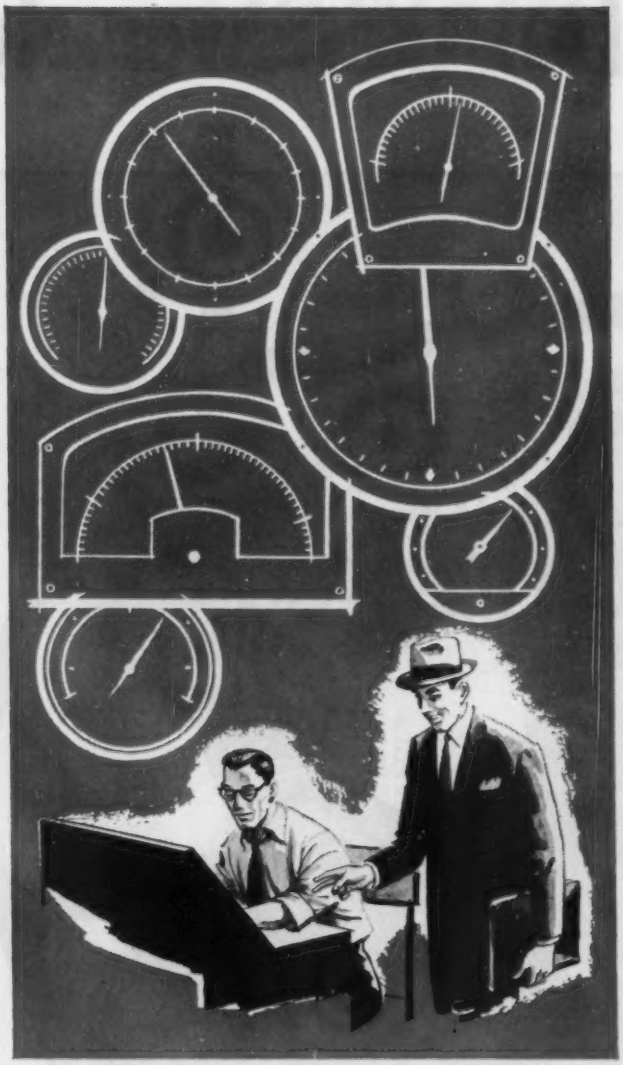
ANNIN VALVES are the only valves that meet the rigorous requirements of the missile program and the exacting demands of the modern process industries in a single standard construction at no premium.

- **MANAGEMENT** prefers Annin Valves because of low initial cost and low maintenance and spare parts inventory.
- **PRODUCTION** men prefer Annin Valves because of longer on-stream service and better product control.
- **MAINTENANCE** men prefer Annin Valves because of ease of maintenance and simplicity of modification for other services.

ANNIN *Control* **VALVES**

THE ANNIN COMPANY
DIVISION OF THE ANNIN CORPORATION
6570 Telegraph Road, Los Angeles 22, California

For more data on advertised products, use Readers' Service Cards, last page.

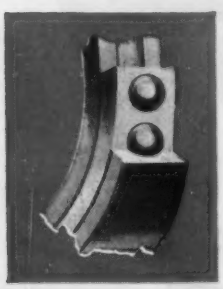


Out of our working partnership with refiners came

CYANAMID'S "BALANCED PERFORMANCE" Aerocat® CATALYSTS

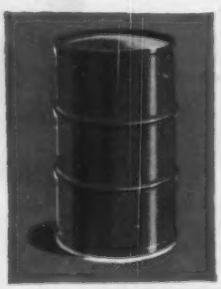
to give new highs in cracking efficiency!

It's *results* that count . . . and in working with the refining industry to get better yields, Cyanamid has pinpointed numerous variables, all affecting performance in catalytic units. These properties have been balanced for greatest field performance efficiency in AEROCAT Catalysts . . . now made even better, thanks to expanded and improved manufacturing facilities. Your evaluation of AEROCAT Catalysts is invited. Our technical service and research staffs will do their best to help you get on stream to greater productivity.



LUBE OIL ADDITIVES

The Cyanamid AEROLUBE® series of lube oil additives are formulated to meet the varying requirements of different base stocks. AEROLUBE 93-C, a concentrated inhibitor with superior anti-wear characteristics, rounds out our line of general purpose inhibitor-detergents.



HDS FOR HIGH SULFURS

Conversion of high-sulfur fractions to H_2S is most effectively accomplished with Cyanamid AERO® HDS, cobalt-molybdena desulfurization catalysts. AERO HDS catalysts have highest available pore volume, excellent mechanical properties and low bulk densities.

CYANAMID

AMERICAN CYANAMID COMPANY
REFINERY CHEMICALS DEPARTMENT
30 Rockefeller Plaza, New York 20, N. Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

The petroleum catalyst facilities of Cyanamid's research laboratories at Stamford, Connecticut, are unique in the petroleum industry. Through them, Cyanamid maintains its lead in the development of superior catalyst products.

For more data on advertised products, use Readers' Service Cards, last page.

DUAL METAL... answer to

What is it ?

To thirty-one of America's largest industries with problems of abrasion or corrosion — or both —"Dual Metal" means U. S. Pipe's Steel and Tubes Division.

Specifically, "Dual Metal" is our name for centrifugally cast cylindrical sections in which two dissimilar metals are bonded metallurgically by centrifugal force and temperature.

"Dual Metal" centrifugally cast, integrally fused combinations of two dissimilar metals are doing industry's most difficult and exacting jobs better and more economically than ever before.

Design engineers have been quick to recognize the outstanding merits of a process capable of combining the desired mechanical and chemical properties no single metal possesses.

"Dual Metal" means versatility, efficiency and economy.

Research and development play a vital and important role in the centrifugal casting of "Dual Metal" combinations. Our Pilot Foundry is devoted entirely to process and product improvement.

UNITED STATES PIPE & FOUNDRY CO.

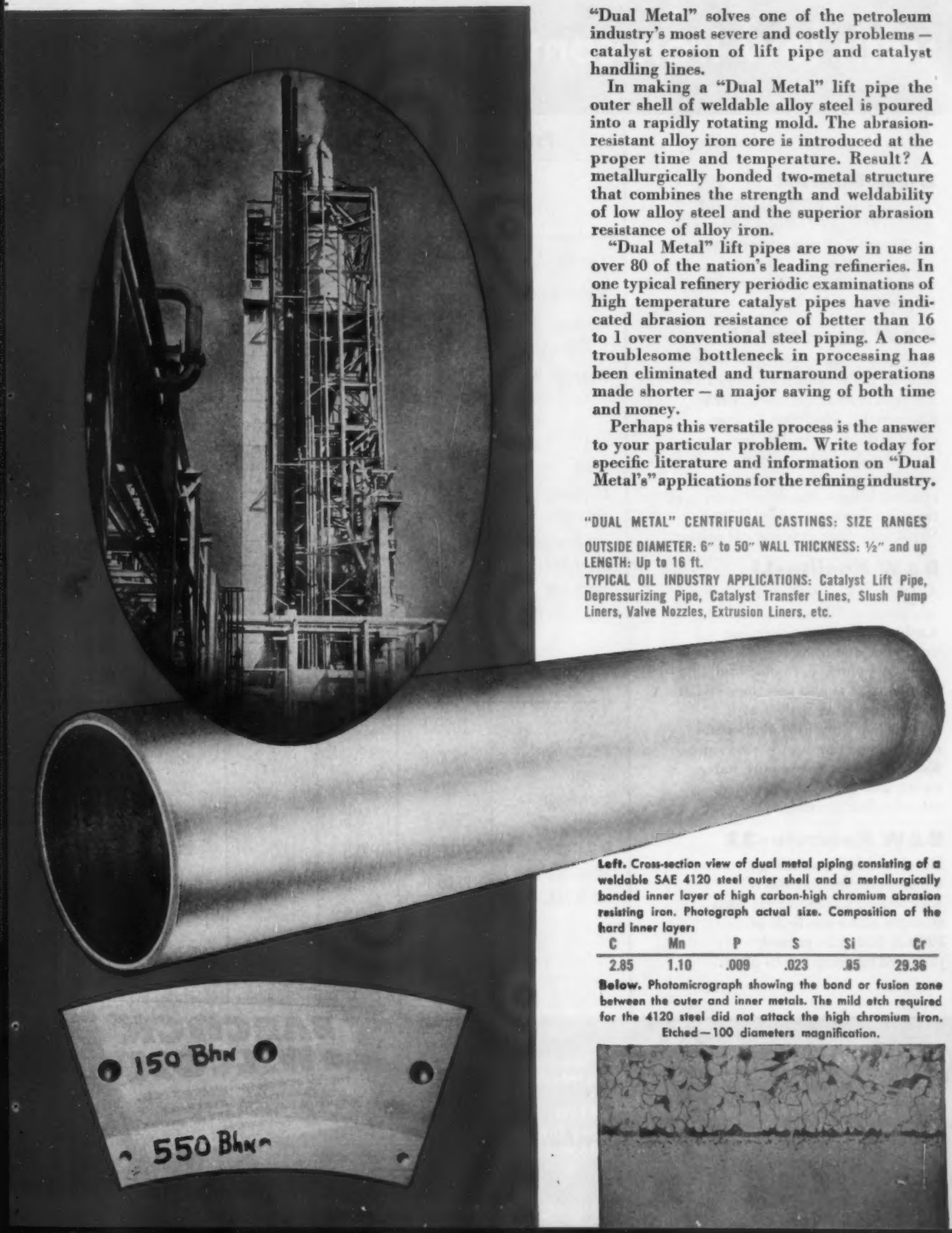
Steel and Tubes Division

STEEL & TUBES U.S. PIPE DIVISION

BURLINGTON, NEW JERSEY

SALES OFFICES: LOS ANGELES, SAN FRANCISCO, CHICAGO, ST. LOUIS, COLUMBUS, DETROIT, PITTSBURGH, HARTFORD, BURLINGTON

your TURNAROUND problems



"Dual Metal" solves one of the petroleum industry's most severe and costly problems — catalyst erosion of lift pipe and catalyst handling lines.

In making a "Dual Metal" lift pipe the outer shell of weldable alloy steel is poured into a rapidly rotating mold. The abrasion-resistant alloy iron core is introduced at the proper time and temperature. Result? A metallurgically bonded two-metal structure that combines the strength and weldability of low alloy steel and the superior abrasion resistance of alloy iron.

"Dual Metal" lift pipes are now in use in over 80 of the nation's leading refineries. In one typical refinery periodic examinations of high temperature catalyst pipes have indicated abrasion resistance of better than 16 to 1 over conventional steel piping. A once-troublesome bottleneck in processing has been eliminated and turnaround operations made shorter — a major saving of both time and money.

Perhaps this versatile process is the answer to your particular problem. Write today for specific literature and information on "Dual Metal's" applications for the refining industry.

"DUAL METAL" CENTRIFUGAL CASTINGS: SIZE RANGES

OUTSIDE DIAMETER: 6" to 50" WALL THICKNESS: ½" and up
LENGTH: Up to 16 ft.
TYPICAL OIL INDUSTRY APPLICATIONS: Catalyst Lift Pipe, Depressurizing Pipe, Catalyst Transfer Lines, Slush Pump Liners, Valve Nozzles, Extrusion Liners, etc.

Left. Cross-section view of dual metal piping consisting of a weldable SAE 4120 steel outer shell and a metallurgically bonded inner layer of high carbon-high chromium abrasion resisting iron. Photograph actual size. Composition of the hard inner layer:

C	Mn	P	S	Si	Cr
2.85	1.10	.009	.023	.85	29.36

Below. Photomicrograph showing the bond or fusion zone between the outer and inner metals. The mild etch required for the 4120 steel did not attack the high chromium iron. Etched — 100 diameters magnification.

FOR CATALYTIC REFORMING

4 B&W Refractory Castables

with low iron content

B&W Kaocast

Ten years ago, B&W introduced this 3000° castable which offers a combination of high temperature use limit, as well as very low iron content. B&W Kaocast can either be gunned or cast in place.

B&W Kaocrete-LI

After two years of extensive field service, B&W adds Kaocrete-LI to low iron content castables. B&W Kaocrete-LI, which has an iron content of less than 1%, has exceptionally high strength for resistance against abrasion and erosion. It has sufficient refractoriness for use at temperatures to 2700 F. Suitable for both gunning and casting.

B&W Kaolite-LI

Another new castable with over two years of field service, B&W Kaolite-LI has high insulating properties due to its light weight (only 59 pounds per cubic foot). Its iron content is also less than 1%. It is designed to be applied with a cement gun only. Installation and maintenance time can be cut since Kaolite-LI does not require water curing and heat can be applied directly after gunning.

B&W Kaocrete-32

Developed for special high temperature service, B&W Kaocrete-32 has extremely high strength and a use limit of 3200 F. It can be poured, plastered or gunned into place.

Properties of B&W Low Iron Content Castables

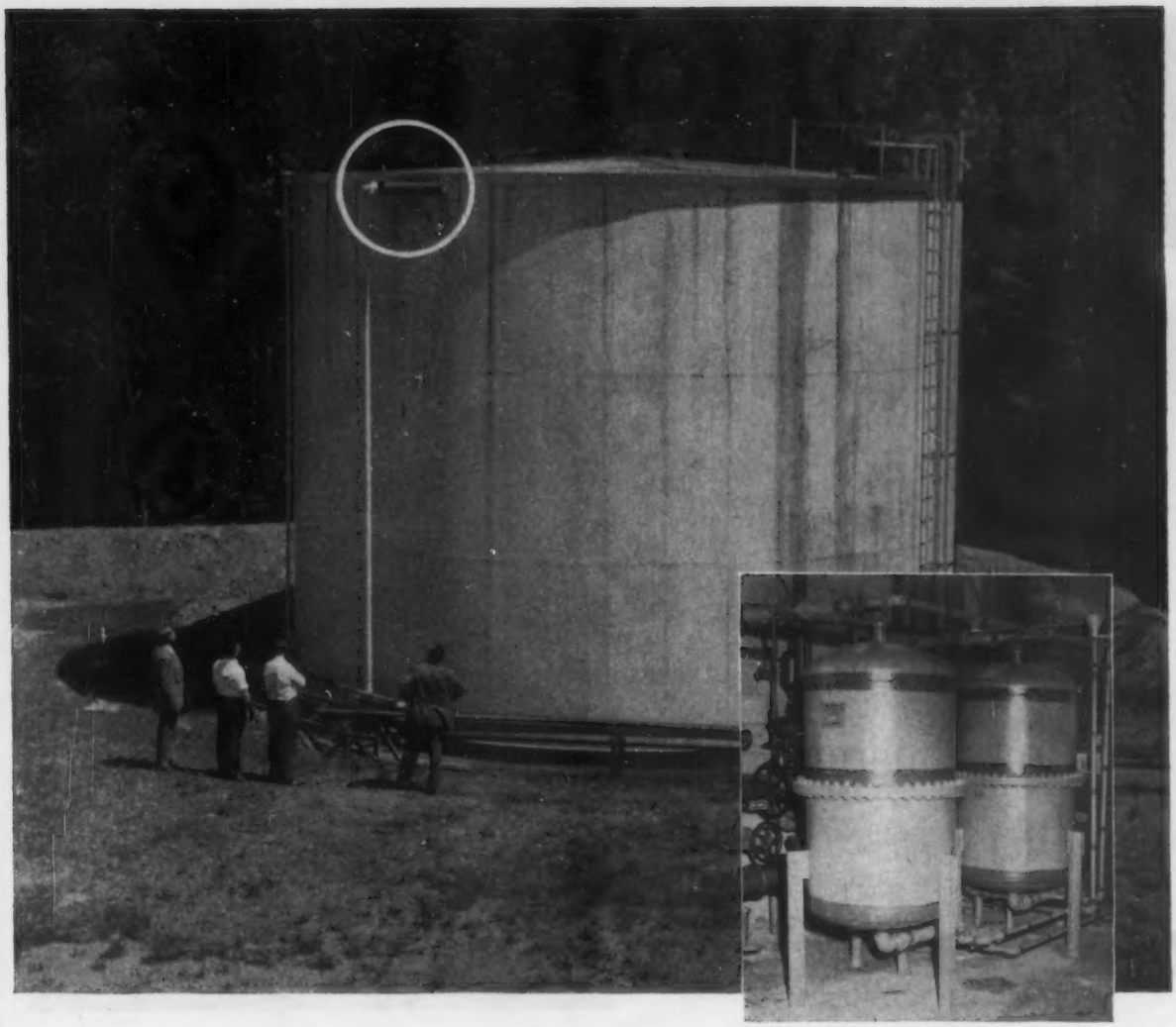
		B&W Kaocast	B&W Kaocrete LI	B&W Kaolite LI	B&W Kaocrete 32
Use limit, °F		3000	2700	2300	3200
Melting point, °F		3200	3100	2700	3297
Average density lb/cu ft after firing		126	131	59	134
Average % Fe_2O_3		1.0	0.9	0.8	1.0
Cold crushing strength—psi average—after heating for 5 hrs. at:	1000 F	700	2500	350	1000
	1500 F	500	2500	350	800
	2000 F	400	1200	300	750
	2200 F	500	1300	450	1000
	2400 F	500	1600	—	2000
	2600 F	1000	6000	—	3000
	2800 F	2200	—	—	3500
	3000 F	3500	—	—	4000
	3200 F	—	—	—	5000
Permanent linear shrinkage—average % less than—after heating for 5 hrs. at:	1000 F	0.3	0.2	0.3	0.2
	1500 F	0.3	0.2	0.4	0.2
	2000 F	0.5	0.2	0.4	0.2
	2200 F	0.5	0.2	0.6	0.4
	2400 F	0.5	+0.1	—	0.5
	2600 F	0.5	—	—	0.5
	2800 F	0.5	—	—	0.5
	3000 F	0.3	—	—	0.2
	3200 F	—	—	—	0.1

Consult your B&W Representative for additional information on these and other B&W Refractories for the refining industry.

B&W REFRACTORIES PRODUCTS: B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.



A blanket for this big baby?

Sure . . . it's in the two little tanks . . . a blanket of Foam

The big tank is full of Styrene, great stuff for the plastics business.

A Styrene fire out of control, like any fire, can be dangerous. The best way to fight it? Throw a blanket of Rockwood FOAM over it.

On top of this big baby full of Styrene is the business end of a Rockwood Fixed FOAM System (in the circle). It'll throw a FOAM blanket over the tank in seconds — if a fire ever starts.

The FOAM liquid is kept, ready to go any time, in the Rockwood diaphragm-type storage tanks on the right.

Do you have a baby like this — full of some flammable liquid? Is a Rockwood Fixed FOAM System ready with a blanket — just in case? Use the coupon to send for the informative booklet.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

Distributors in all principal cities

ROCKWOOD SPRINKLER COMPANY
Portable Fire Protection Division
2081 Harlow Street
Worcester 5, Mass.

Please send me your illustrated booklet on Rockwood fire fighting products.

Name.....

Title.....

Company.....

Street.....

City.....Zone..State.....

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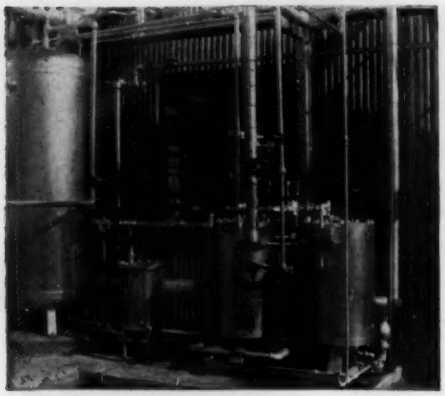
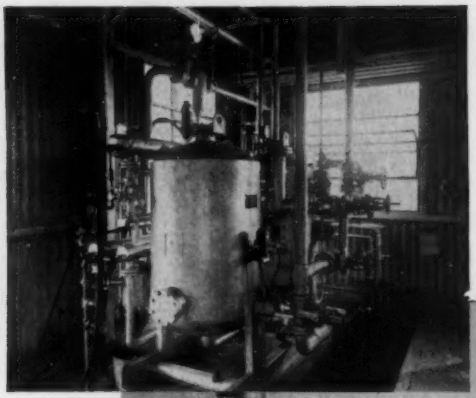
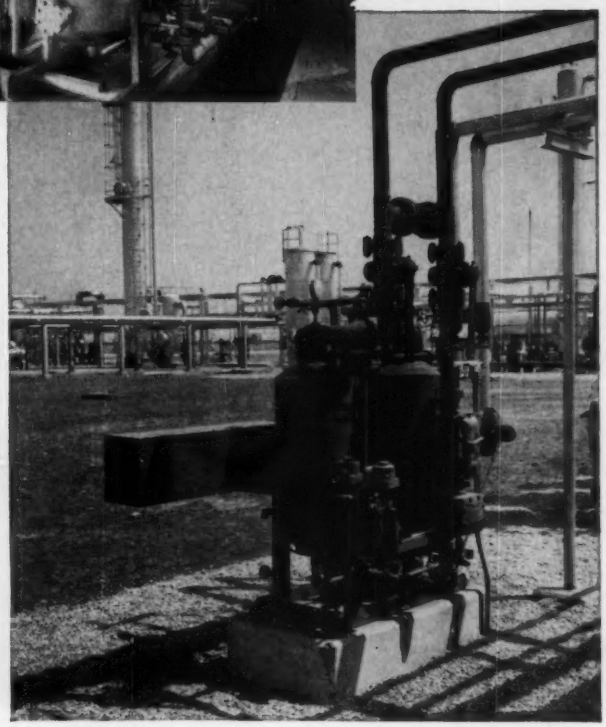






Because AUTOMATION can't tolerate errors, controls operate on DRY air

Lectrodryer does that DRYing*

THESE INSTRUMENT air driers are typical of many scattered throughout the Petroleum and Chemical industries. Some Lectrodryers are huge. But all go about their DRYing job efficiently and dependably, requiring very little attention. They "automate" DRYing.

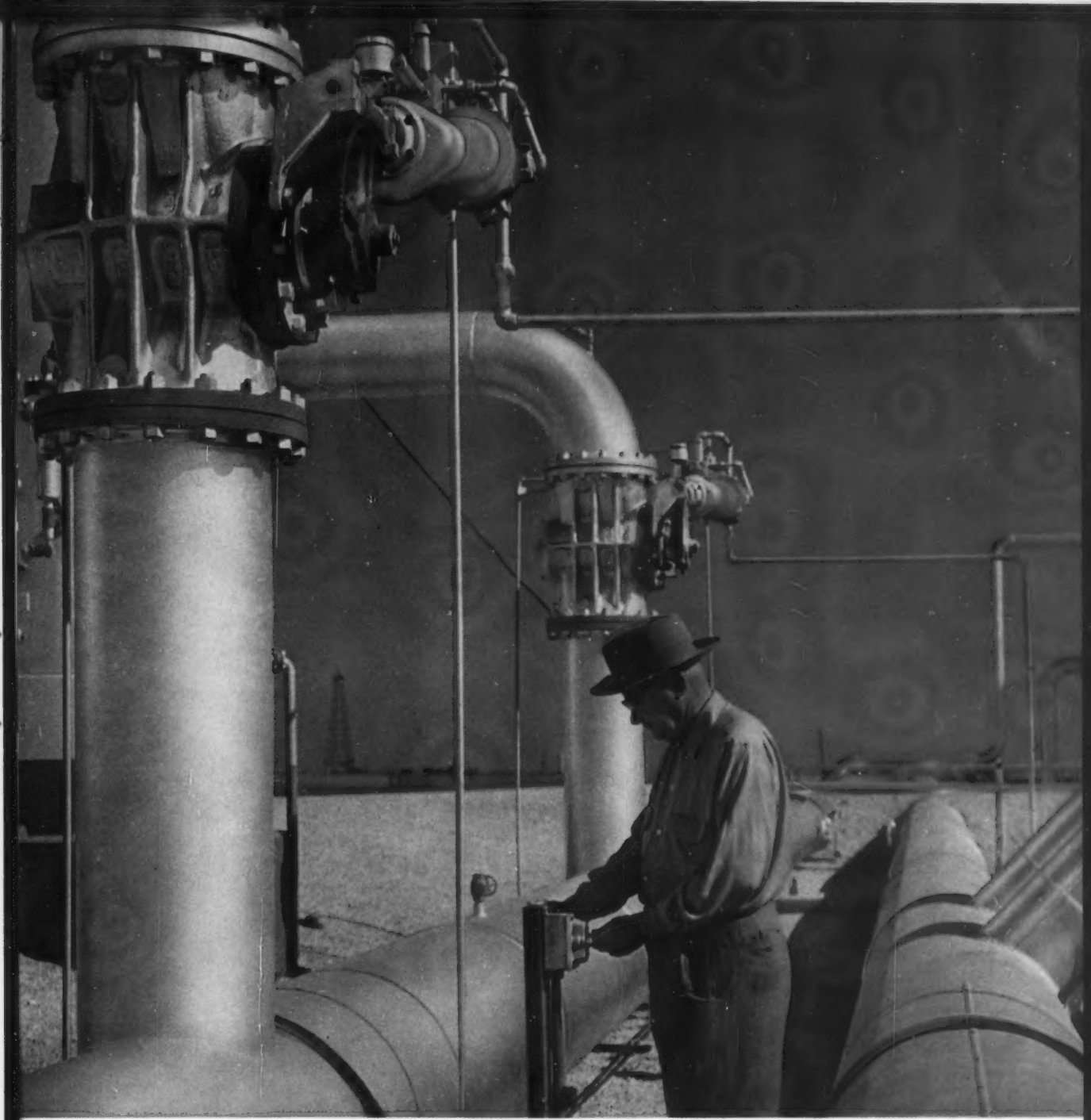
Pipe lines, natural gasoline plants and refineries—remotely-controlled processing plants—all assure dependability of their automatic operations by installing Lectrodryers to DRY the air fed to instruments and air-motors. Thus, regardless of weather conditions, there's no moisture in the compressed air to cause freeze-ups, form rust or mud to clog delicate ports.

Add a Lectrodryer to the aftercoolers and separators now on your air system and catch the vaporous moisture that will otherwise cause trouble as the air cools. Bulletin 223-A describes these instrument air driers. For a copy, write Pittsburgh Lectrodryer Division, McGraw-Edison Company, 307 32nd Street, Pittsburgh 30, Pennsylvania.

In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

Lectrodryer

*REGISTERED TRADEMARK U. S. PAT. OFF.



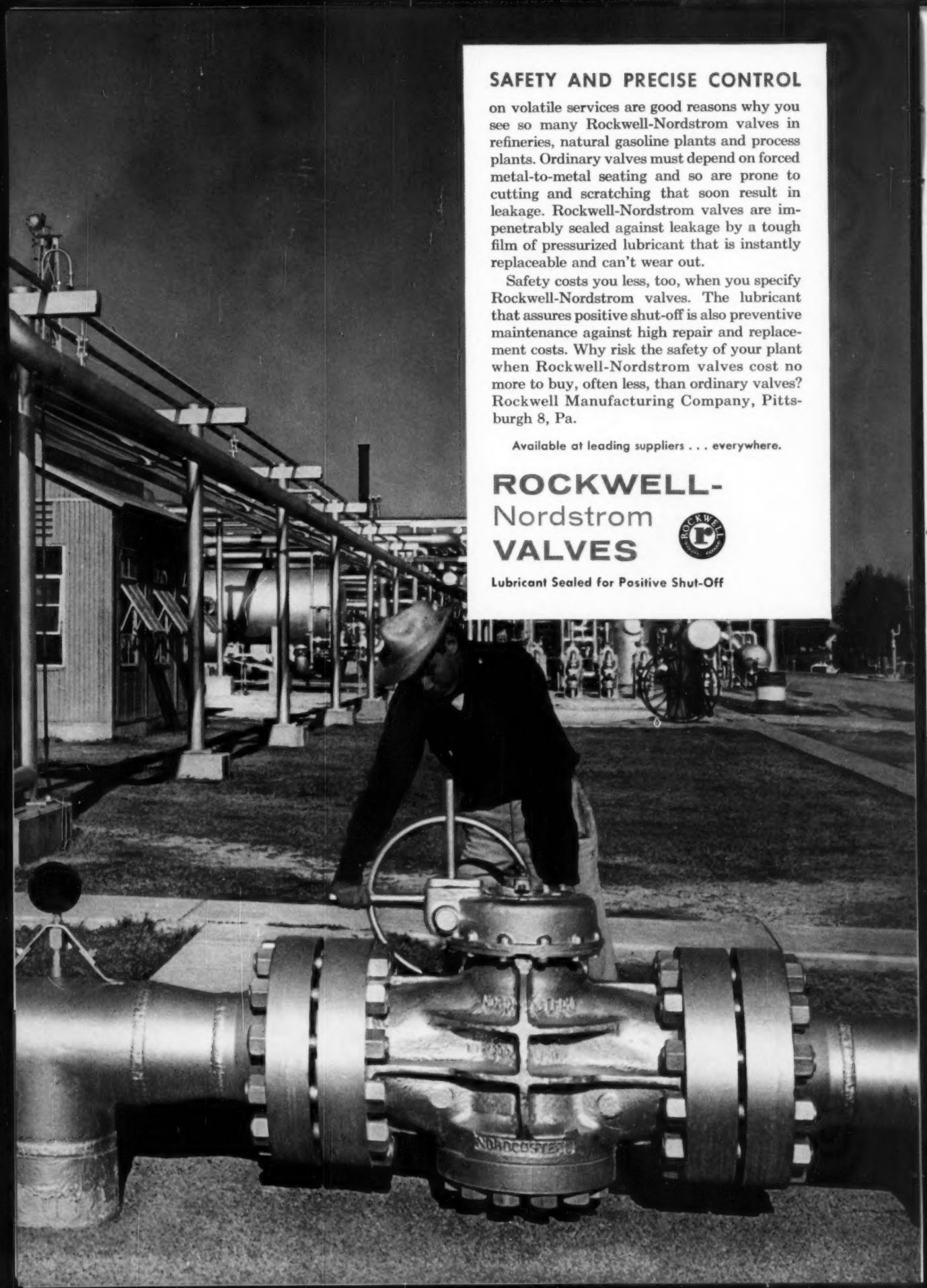
INSTANT, DEPENDABLE RESPONSE to push button or automatic flow control is assured when you specify Rockwell-Nordstrom valves. Their basic advantage for power operation that is lacking in ordinary valves: *lubrication*. Because the plug is seated on a film of pressurized lubricant, a "friction-free" surface keeps the valve ready for instant, smooth operation. And since the lubricant reduces torque and the plug is fully open or closed in a quarter-turn, a simpler, less costly actuator is needed.

Rockwell-Nordstrom valves are available in a complete range of sizes and pressure ratings with electric, pneumatic and cylinder operators. They cost no more to buy—often less—than ordinary valves. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Available at leading suppliers . . . everywhere.

ROCKWELL-
Nordstrom
VALVES

Lubricant Sealed For Positive Shut-Off



SAFETY AND PRECISE CONTROL

on volatile services are good reasons why you see so many Rockwell-Nordstrom valves in refineries, natural gasoline plants and process plants. Ordinary valves must depend on forced metal-to-metal seating and so are prone to cutting and scratching that soon result in leakage. Rockwell-Nordstrom valves are impenetrably sealed against leakage by a tough film of pressurized lubricant that is instantly replaceable and can't wear out.

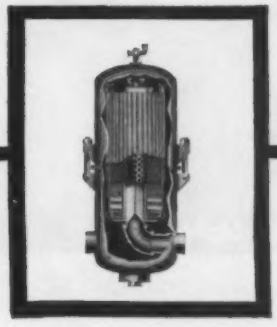
Safety costs you less, too, when you specify Rockwell-Nordstrom valves. The lubricant that assures positive shut-off is also preventive maintenance against high repair and replacement costs. Why risk the safety of your plant when Rockwell-Nordstrom valves cost no more to buy, often less, than ordinary valves? Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Available at leading suppliers . . . everywhere.

ROCKWELL-
Nordstrom
VALVES

Lubricant Sealed for Positive Shut-Off

KEEP IT CLEAN by Phil Tration



An inscrutable Bar-keep named Hugh
made martinis in Filters, "Staynew."
The results were uncouth—all gin, no vermouth
But, oh how his clientele grew!

Howsomever, the uses for Dollinger Filters do seem unlimited. Every day some bright engineer figures out a new way to save his company money just by installing the right filter, at the right place in a liquid, gas, or air line. (Be surprised what that does for the engineer's reputation too.)

If you have an idea for saving money with filters, and you'd like to talk with someone about it . . . may we suggest you contact someone with a *complete* line, someone with a little "know-how," someone with a reputation for quality . . . someone like your Dollinger sales engineer.

STAYNEW MODEL ELS LIQUID FILTER

Practically any liquid can be successfully filtered with these Dollinger Filters. Their world-wide use on hundreds of different jobs is adequate proof of their versatility. Any filtering material is available for every problem regardless of temperature, pressure, or efficiency desired. Filter bodies are available in steel, stainless, monel, herculoy and other non-corrosive metals.

Why not talk your filtration problem over with a Dollinger representative . . . or send for 12-page Bulletin 300. It illustrates and describes Dollinger Liquid Filters and their recommended uses. Dollinger Corporation, 47 Centre Park, Rochester 3, N. Y.

U.S. PROTECTOMOTOR U.S. PAT. OFF.

STAYNEW DOLLINGER FILTERS

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS HIGH PRESSURE FILTERS • AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

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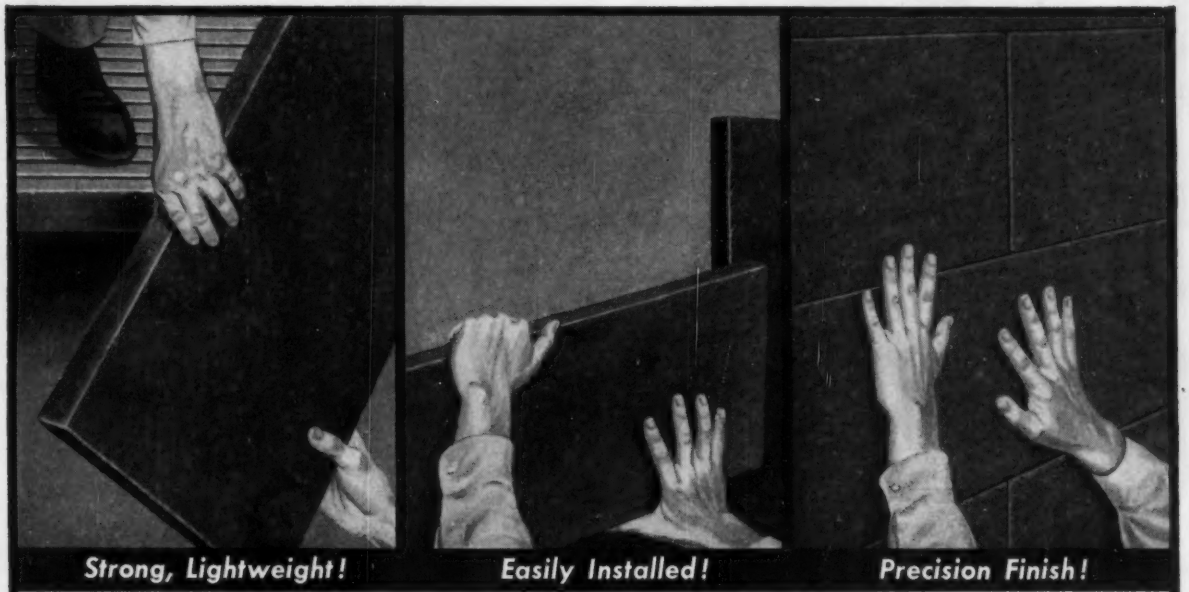
A TRUE-CUT BLOCK WITH PRECISION-FINISH!

EAGLE-PICHER

PV SUPERTEMP
BLOCK INSULATION



Strong, Lightweight! *Easily Installed!* *Precision Finish!*

- Eagle-Picher's "precision-finish" is one of the most important insulation developments in years.
- Highly efficient, all-purpose block that is practically dustless.
- Great structural strength! Meets rigid demands for long-lasting block able to withstand wide temperature range up to 1900 F.
- Lightweight, easily installed! Easily cut to fit irregular areas—no special tools needed. Requires only minimum reinforcing.
- Effectively resists steam and other moisture! Does not disintegrate or lose thermal efficiency under heavy duty service.

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

FREE SAMPLE!

Write Today!

Eagle-Picher PV Supertemp Block conforms to Commercial Standard CS 117.

Since 1843

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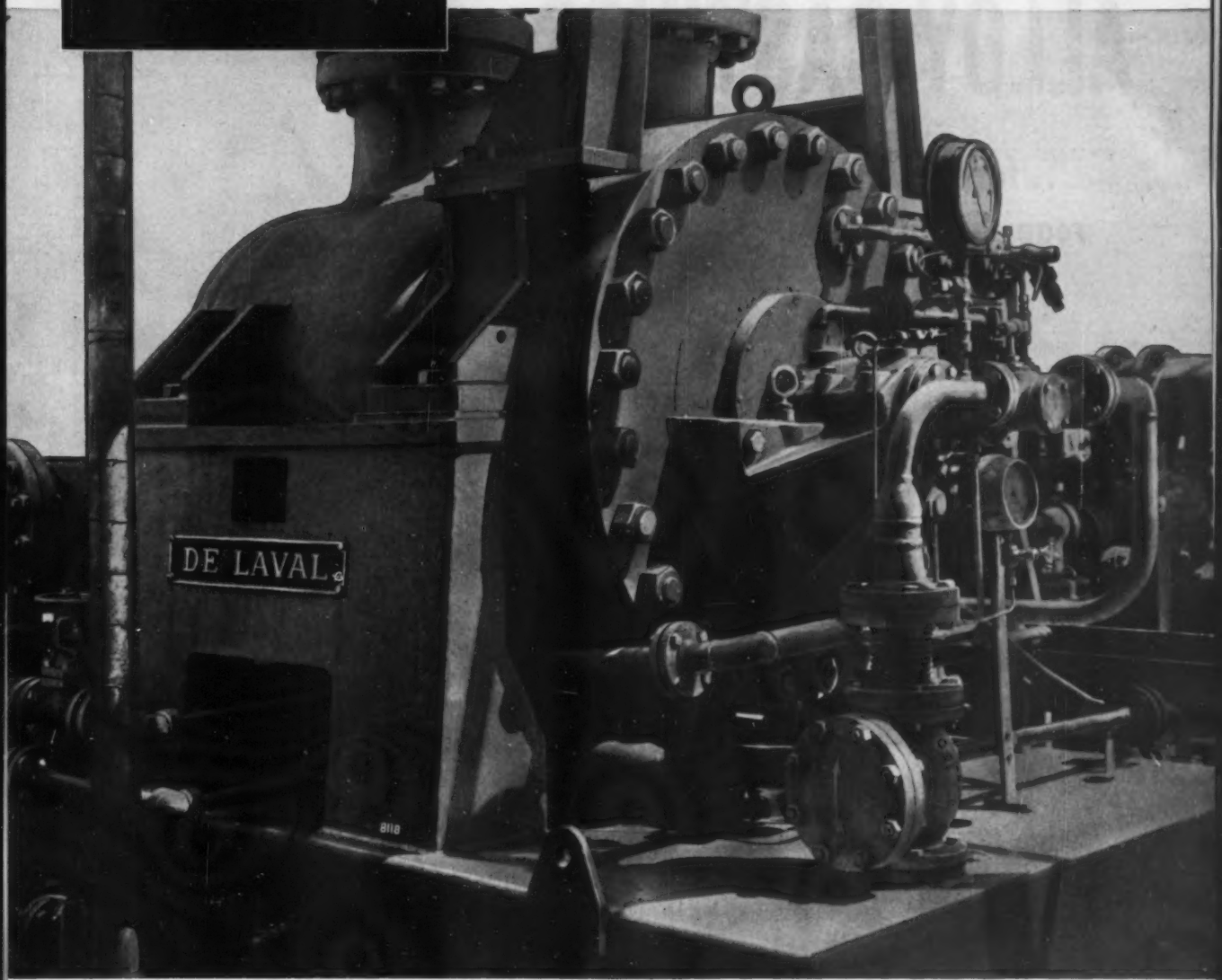
The Eagle-Picher Company • General Offices: Cincinnati 1, Ohio

(*Member of Industrial Mineral Fiber Institute*)

DE LAVAL

BARREL TYPE REFINERY COMPRESSOR

handles hydrogen under high pressures in a reformer at General Petroleum



Send for new Bulletin 0504

This De Laval centrifugal recycle barrel type compressor is doing a dependable job handling hydrogen under high pressures at the General Petroleum plant in Ferndale, Washington. It takes hydrogen at an inlet pressure of 500 psig and discharges it at 625 psig. The unit is driven by a 1110 hp turbine operating at 9900 rpm.

General Petroleum Corporation is only one of many refiners who have specified De Laval Compressors. Whether you need to handle light or heavy gases at high or low pressures in catalytic cracking, reforming, alkylation, coking or any similar service, it pays to look to De Laval. Rugged De Laval centrifugal compressors perform dependably in heavy-duty continuous operation. De Laval has more than 40 years of experience in solving gas compression problems.

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY

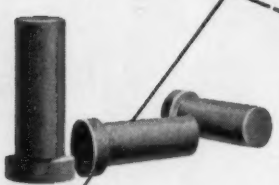
811 Nottingham Way, Trenton 2, New York

DL-367

AIRCRAFT QUALITY

ALLOY CASTINGS

... for the special requirements of your industry



METALS PROCESSING DIVISION FOUNDRY handles wide range of sizes, closely controls dimensions

Precision testing methods provide close control of casting quality

Curtiss-Wright's Metals Processing Division today offers your industry precision castings of critical parts in a wide variety of sizes, and with closely controlled dimensions. For example, in the large casting shown, tolerance is ±.030 over 36″ diameter. From its modern, completely equipped foundry in Buffalo, the Division supplies heat, corrosion and abrasion resistant castings from a full range of special-property alloys, including ductile iron... by sand, centrifugal, ceramic or shell processes.

Precision alloying techniques, modern melting controls with spectrometer testing, X-ray control by experienced radiographers — all add up to castings with superior physical and mechanical properties . . . mean better and more dependable products for the critical needs of industry. Qualified design engineering assistance is a part of the comprehensive Metals Processing Division service. Write for details.

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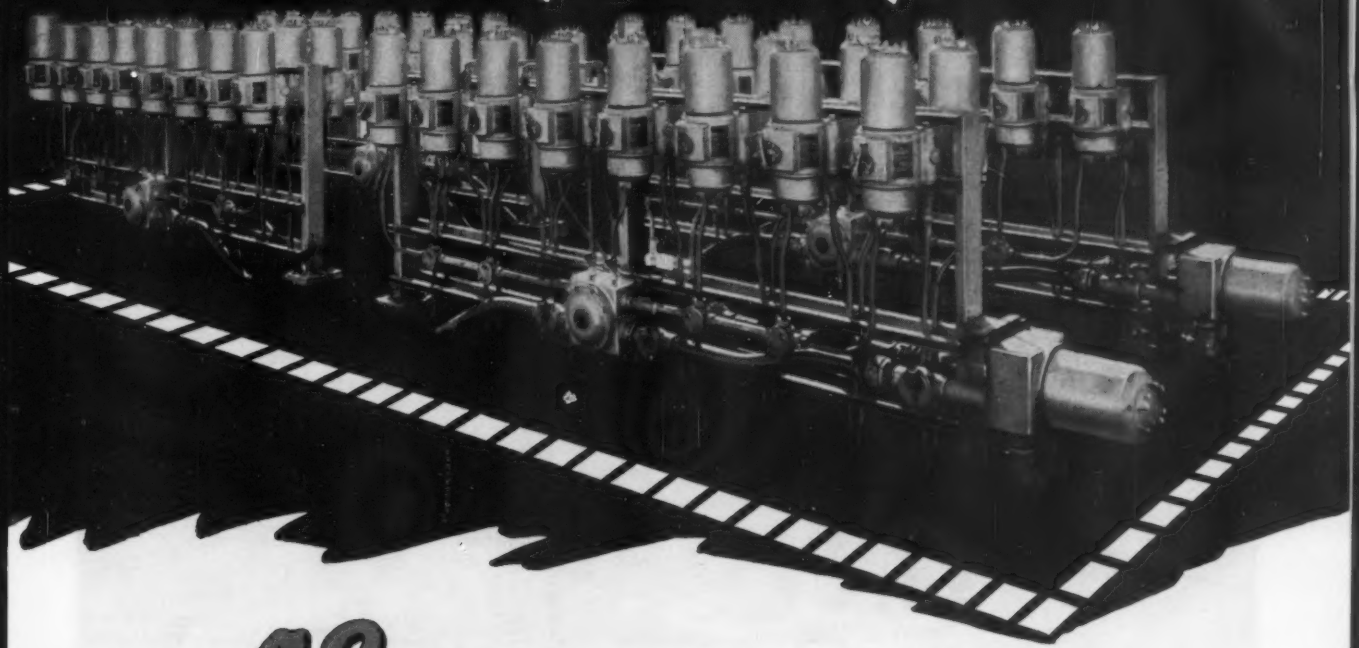
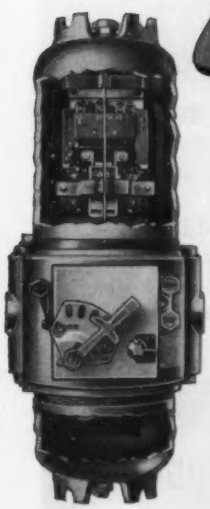
METALS PROCESSING DIVISION
CURTISS-WRIGHT CORPORATION • BUFFALO, N. Y.

Metals Processing Division Branch Offices: New York • Houston • Los Angeles

CROUSE-HINDS
Condulet* motor controls
Occupy Less Space!





48 Explosion-Proof Combination Motor Starters and Circuit Breakers . . . *in a 25 ft. x 6 ft. Area!*

Crouse-Hinds Condulet* Type EPC Motor Starters and Circuit Breakers are explosion-proof, dust-tight (dust-ignition-proof) and weather-resistant (raintight).

Lightweight cast aluminum construction for easy installation without use of lifting equipment.

Seven Conduit entrances simplify installation.

Built-in push button stations and selector switches are available.

Starter sizes 0 to 5. Circuit breakers 50 to 600-amp. frame sizes.

In the installation shown above, 48 Crouse-Hinds Condulet* Type EPC combination motor starters and circuit breakers are compactly arranged in four racks.

If necessary, the 25 ft. x 6 ft. area used could have been cut in half by installing the Condulet motor controls in two tiers. Or, *twice* as many Condulet controls could have been installed in the same area, if required.

The *vertical design* of Crouse-Hinds motor starters, circuit breakers and combinations allows them to be installed only ¼" apart. This compactness produces savings in the construction of steel mounting racks, and in the use of premium floor space.

● **For help in solving a space problem, see your Crouse-Hinds distributor . . . or call the nearest Office listed below**

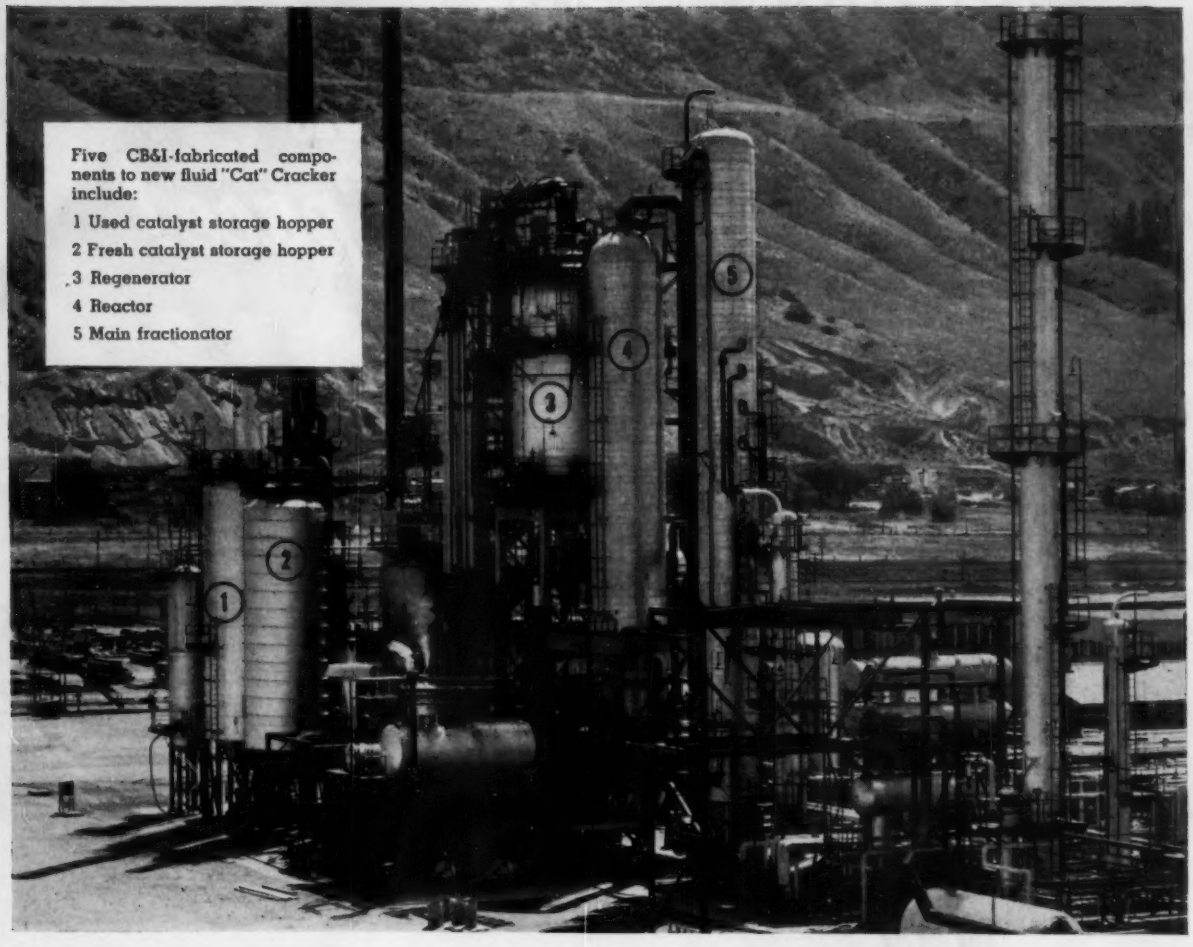
*Registered

A NATIONWIDE **DISTRIBUTION** exclusively through **ELECTRICAL DISTRIBUTORS**

CROUSE-HINDS COMPANY

Main Office and Factory: Syracuse, N. Y.

Offices: Buffalo Boston Birmingham Butte Baltimore Atlanta Cincinnati Chicago Cleveland Dallas Denver Detroit Houston Indianapolis Kansas City Los Angeles Minneapolis New Orleans New York Philadelphia Pittsburgh Portland, Ore. San Francisco Seattle Tulsa Washington REPRESENTATIVES: Albany Albuquerque Beaumont Charleston Cincinnati Corpus Christi Fargo Richmond Va. Shreveport Canada: Toronto Montreal Vancouver Winnipeg



3 FOLD Expansion served by CB&I Structures

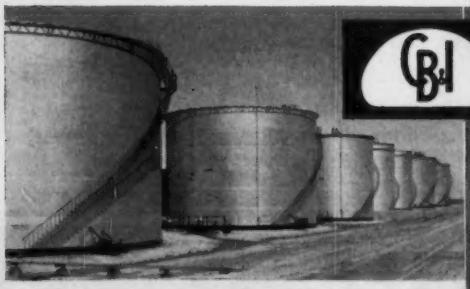
new "Cat" Cracker boosts Salt Lake Refining Company gasoline output by 20%

Included in the most recent expansion program of the Salt Lake Refining Company were CB&I-fabricated components for the new fluid catalytic cracking unit shown above.

The new "cracker", furnished through Fluor Corporation, has boosted gasoline output by 20%. The building of additional Horton® Floating Roof tanks now brings Salt Lake's storage capacity to more than 1,600,000 barrels.

Whether *you're* building new, or adding to . . . the *complete* facilities for design, fabrication and erection offered by CB&I can meet your most *specific* needs for petroleum storage or processing structures. Write for details.

P54



These Horton Double-Deck Floating Roof tanks are some of the 63 CB&I tanks located at Salt Lake Refining Company.

CB&I

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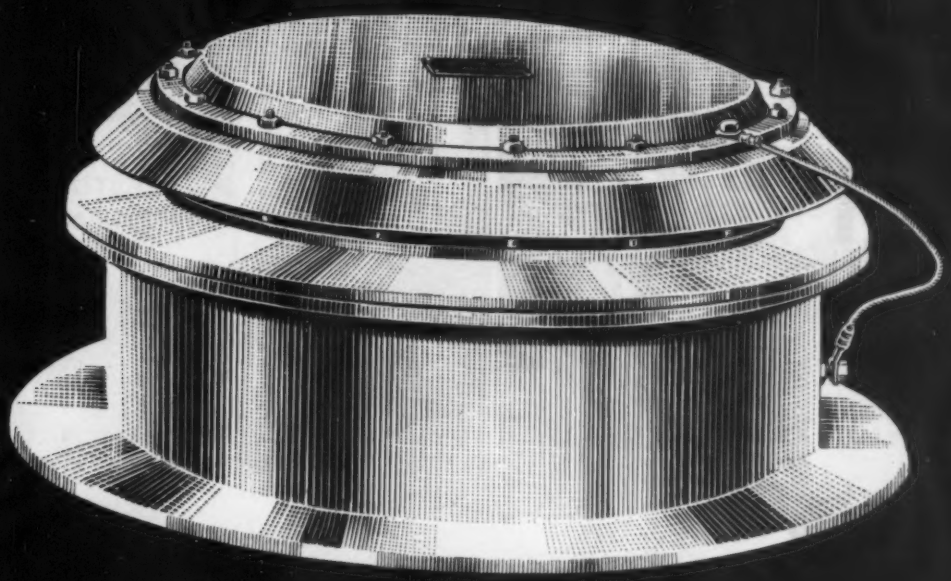
Horton Steel Works Limited, Toronto; Chicago Bridge & Iron Company Ltd., Caracas; Chicago Bridge Limited, London; Sociedade Chibridge de Construcoes Ltda., Rio de Janeiro.

20″ Emergency Pressure and Vacuum Relief



Illustrated here is the new S. & J. Model ST-5455 PV Emergency Vent, designed to cope with excessive internal pressure and vacuum conditions in above ground tanks of unlimited size.

Adapted to the standard 20″ A.P.I. manhole, this emergency vent is sturdily constructed to resist mis-shaping by manhole flanges not perfectly flat. Entire cover can be lifted off base in a matter of seconds, providing clear and unobstructed passage through the 20″ opening. No gaskets to replace—no unbolting is involved—removal speed is paramount.

Cover serves as pallet, and under severe conditions may rise out of manhole completely. A safety cable fastens cover to the base. Standard loading for pressure relief 1 oz./sq. in. and ¾″ water for vacuum relief. Interested engineers are invited to request a copy of Engineering Data Sheet.

S&J

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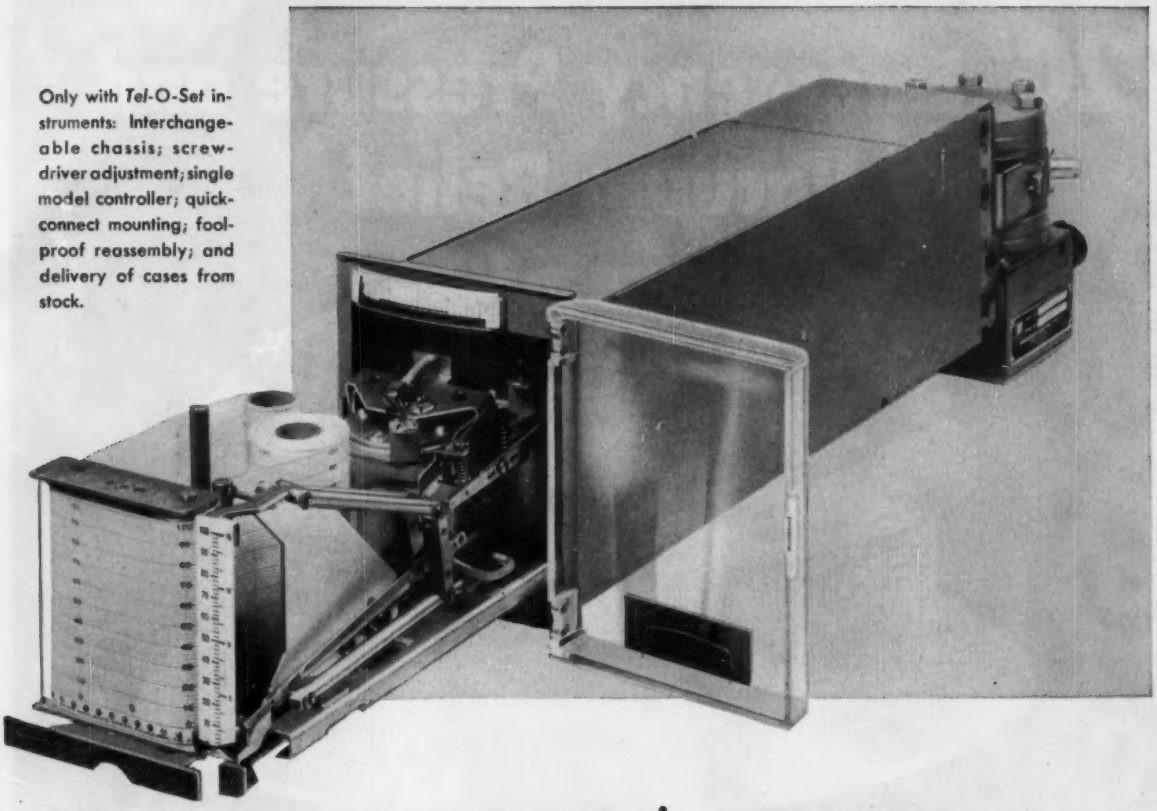
For more data on advertised products, use Readers' Service Cards, last page.

Only with *Tel-O-Set* instruments: Interchangeable chassis; screwdriver adjustment; single model controller; quick-connect mounting; foolproof reassembly; and delivery of cases from stock.



you save in many ways . . .

with HONEYWELL TEL-O-SET* Miniature Instruments

New, improved *Tel-O-Set* miniature pneumatic instruments give you across-the-board savings in downtime . . . maintenance costs . . . spare parts stocking . . . personnel training.

Here are some of the reasons for *Tel-O-Set* versatility and economy: You can change a recorder to an indicator or vice versa without interrupting control, simply by pulling out one chassis and sliding another in place. All parts can be inspected during operation, without process interruption. The pneumatic assembly, consisting of a regulator and switches, can be removed from the rear of the case *without disturbing electrical connections.*

*Trademark of Minneapolis-Honeywell Regulator Co.

Controllers have quick-connect switch permitting removal while process remains on manual control. All instruments are installed and serviced with utmost simplicity.

For complete information on *Tel-O-Set* instruments, write for Catalog C-1001-1, or phone your nearby Honeywell sales engineer. He's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

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BROWN INSTRUMENTS

H HONEYWELL First in Controls

DU PONT *Petroleum Chemicals* NEWS

One of a Series of Bulletins for the Petroleum Industry

JUNE 1957

World's first TEL tank-ship commissioned

NEW ASSISTANT REGIONAL MANAGER

WILLIAM W. WINGATE was recently appointed assistant regional manager in the Petroleum Chemicals Division's Mid-Continent Region, with headquarters in Tulsa, Oklahoma. He replaces Barrett B. Russell, III, who has been transferred to the Gulf Coast Region in a similar capacity.

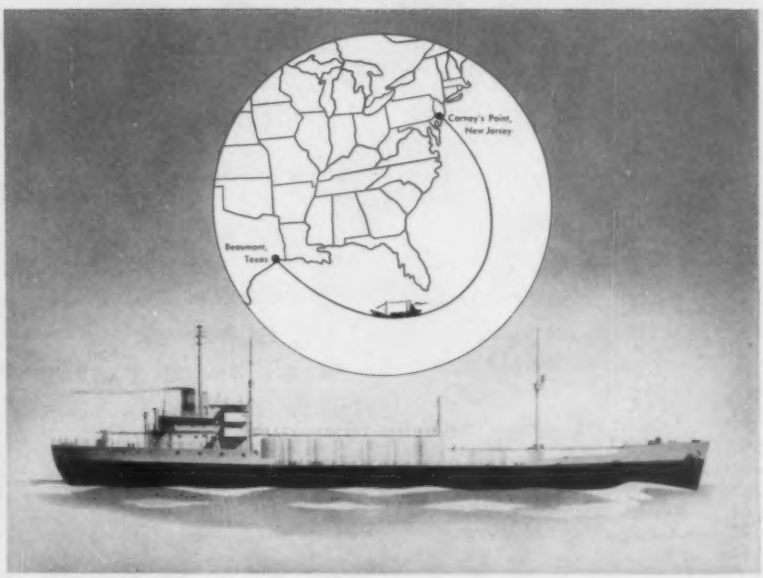
Previously Bill was active in regional sales and technical service work on all Du Pont additives other than tetraethyl lead. This includes Du Pont Estersil GT grease thickener, metal deactivators, lube and fuel oil additives, antioxidants, dyes and grease stabilizers.

Bill Wingate had an early introduction to the oil industry doing gasoline and lube oil testing for Socony-Mobil Oil Company, Inc. while earning his B.S. degree in chemical engineering at the University of Pennsylvania.

During World War II, Wingate was a lieutenant in the Navy and spent three years on submarine duty with the Pacific Fleet.

He is a member of Sigma Xi and Tau Beta Pi.

Rebuilt ship brings convenient Du Pont TEL supply to Gulf Coast refining area



MV PETROCHEM – the first chemical carrier for overwater transport of bulk shipments of TEL antiknock compounds. Rebuilt for the exclusive use of Du Pont, the 6,000-ton tank-ship was recently put into service to meet the expanding needs of Gulf Coast refiners.

SHIP-SUPPLIED STORAGE AND DELIVERY TERMINAL AT BEAUMONT COMPLETED

Another important TEL delivery convenience for Gulf Coast refiners became a reality with the recent rechristening of the MV PETROCHEM – the first TEL tank-ship. This unique ship makes possible a major source of Du Pont TEL supply right in the Gulf Coast area.

Also, TEL handling facilities have been constructed at Beaumont, Texas. These will provide dock accommodations for the new ship, and storage and distribution facilities for its cargo. Thus, the Beaumont terminal is equipped to provide the same TEL-availability and delivery service as Du Pont's manufacturing plants at Carney's Point, New Jersey and Antioch, California.

Bulk shipments

MV PETROCHEM'S maiden voyage marked the first time tetraethyl lead compounds have been transported over water in bulk. To accomplish this safely, the tanker was redesigned and rebuilt, from the hull up, to rigid Du Pont specifica-

OVER

DUPONT *Petroleum Chemicals* NEWS

Diesel locomotive fuel problem solved with Du Pont additive

R. R. SHOP SUPERINTENDENT:
Incompatible economy diesel fuels are causing injector-sticking and filter-plugging that cost us plenty in time and money.

OIL SALESMAN:
We've been hearing that lately. Incompatibility *is* the problem – but there's a way to solve it. I'll tell the refinery about it.

REFINERY EXECUTIVE:
Yes, I've been reading your ads telling how Du Pont's FOA-2 helps eliminate most diesel fuel incompatibility troubles. What about it?

DU PONT REPRESENTATIVE:
That's right, it does! Here, let me show you our data. I'll show your customer, too.

R. R. SHOP SUPERINTENDENT:
This injector's clean as a whistle—and it's been in operation 35 days.

DU PONT REPRESENTATIVE:
In most cases Du Pont FOA-2 keeps fuel oils gum-free. And while it helps prevent injector-sticking, filter-plugging it does not contribute to sparking tendency, because it burns without ash.

CONTINUED

Tanker shipments

tions—so rigid, in fact, that the PETROCHEM meets or exceeds the requirements of any port authority in the world!

TEL to Texas – raw materials back

The converted ship is in reality a two-cargo vessel. Designed primarily to move bulk shipments of TEL south from Carney's Point, it is also equipped with separate tanks for transporting ethyl chloride and ethylene dichloride back to Carney's Point.

Safety for crew and cargo

The PETROCHEM is permanently compartmented, with solid bulkheads dividing the operational and cargo sections. Still other solid bulkheads – welded to the hull itself—separate each of three cargo spaces. Safety and product cleanliness were the primary design considerations.

Unique features

Many new safety features were specially designed for this 6,000-ton tankship. Each compartment is ventilated separately by a system which effects a complete change of air throughout the entire ship every three minutes. A vacuum system is another of the many special facilities for safe maintenance, repair, and product handling.

If you operate a refinery in the Gulf Coast area, the new ship and terminal are your assurance of a nearby ample supply of Du Pont TEL.

Voice of America to broadcast Magic Barrel excerpts

Parts of the oil industry's "Magic Barrel" presentation have been recorded for broadcasting to people behind the iron and bamboo curtains as well as in free countries of the world.

Members of the Voice of America staff first became acquainted with the Du Pont-designed Magic Barrel when visiting the company to develop a special program using the voices of approximately 100 foreign-born and native American Du Pont employees. At this time, the Magic Barrel was shown to the Voice staff to acquaint them with the group of Du Pont products made from oil. They saw in this presentation some of the fruits of American enterprise – presented in a dramatic and convincing fashion. So they asked to have parts of it taped for broadcasting to their listeners.

The Magic Barrel broadcast has been included in a more comprehensive program in 32 languages under the title, "The People's Capitalism."

This program will also explain the widespread sharing of benefits under the American economic system and tell some of the history of the Du Pont Company. Recorded interviews with employees who emigrated from 44 foreign countries will appear on the program, along with company executives, scientists and union representatives. The interviews were all spontaneous . . . no prepared scripts.

The Voice of America program is the first concerted effort to tell the story of an American company in many languages.

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Tulsa 1—1811 So. Baltimore Ave. . . . . LUther 5-5578
In Canada—Du Pont Company of Canada (1956) Limited, Petroleum Chemicals, 85 Eglinton Ave. East, **Toronto 12**—Ontario . . . . . HUdson 1-6461
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OVER

A-4635

Printed in U. S. A.

it takes men of vision to build a better plant

Building is a business of men. Men with vision, with knowledge, with broad experience. Here at Procon we've concentrated on getting and keeping the best of them.

For years, the world over, Procon men have been planning and building refineries, petrochemical and chemical plants . . . to specifications and on schedule, time and again surpassing any reasonable goal.

We're proud of our men at Procon. To us they are truly those men of vision who do build better plants. Together they provide a complete design, engineering and construction service.

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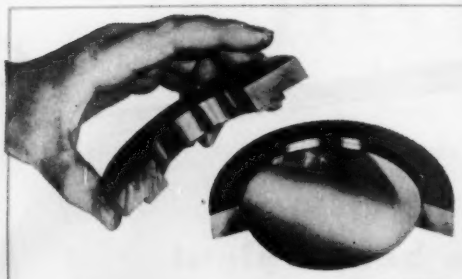
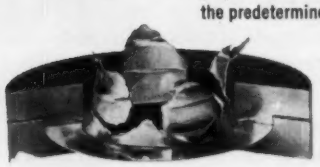


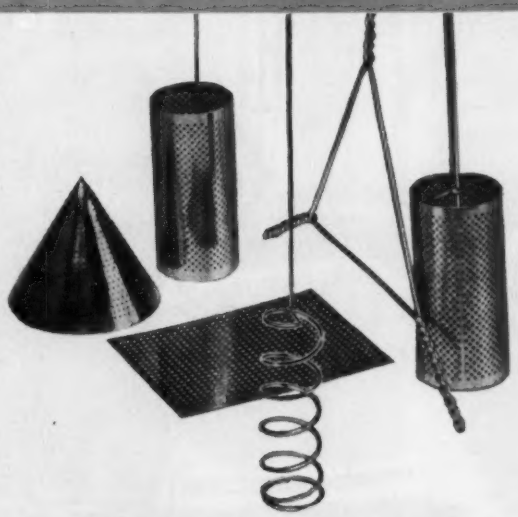
RUPTURE DISCS... discs of precious metals, resistant to most corrosive agents and unattacked under conditions that base metals could not withstand. Specific physical properties ensure bursting only at the predetermined pressure.



DEOXO® PURIFIER... provides low-cost catalytic purification of hydrogen and other gases to the extent of less than one part oxygen per million. Requires no operating expense, no maintenance, no reactivation, no auxiliary heating, no water cooler. Extremely simple installation.

important for petroleum processing...

SUPER-SENSITIVE DEOXO® INDICATOR... for measuring oxygen or hydrogen present as impurities in other gases. Accurately indicates from 0.0002% to 0.0200% (2 to 200 parts per million) oxygen, and from 0.0004% to 0.0400% hydrogen. A dual range permits measurement of up to 0.25% oxygen or 0.5% hydrogen.



LABORATORY WARE... a wide variety of forms and sizes for chemical and physical purposes, made of platinum or any desired alloy. Line includes crucibles, reshapers, triangles, dishes, electrodes, anodes and cathodes.

Write for complete catalog material and details.

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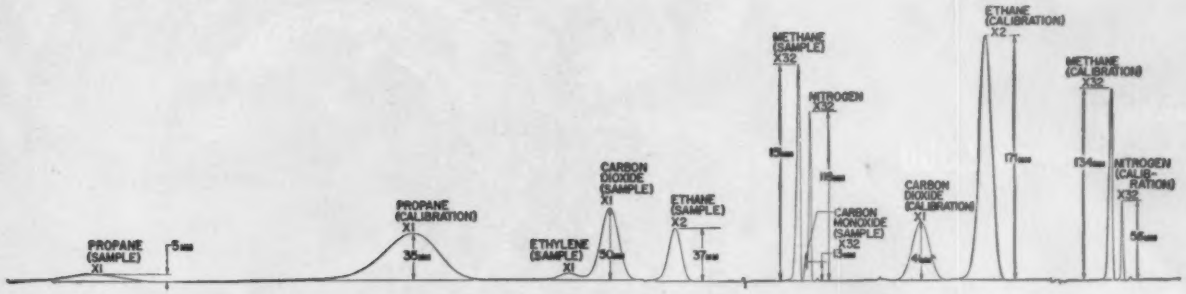


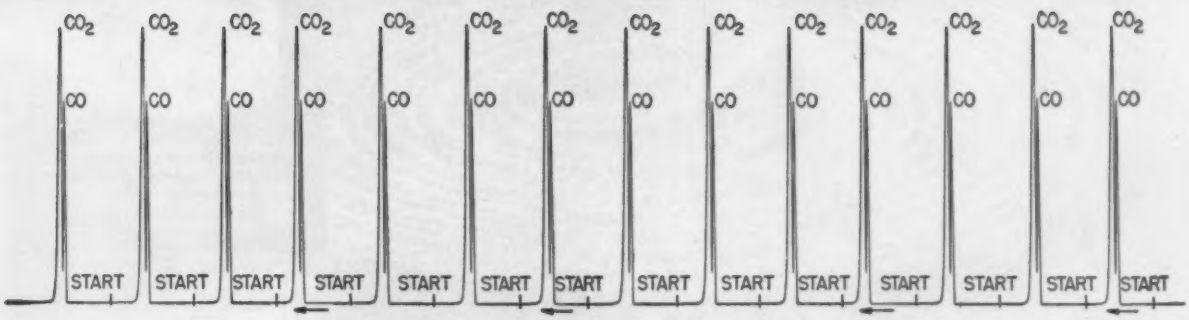
MANUFACTURED GAS SAMPLE

Sample Volume	**1 cc**
Column	**P-E type "J" (2 meters)**
Carrier Gas	**Helium**
Temperature	**25°C.**

This fractogram shows an analysis of a manufactured gas by "intermix calibration" technique (the introduction of a standard gas of known composition into a sample run). Accurate and rapid quantitative results are obtainable since the ratio of corresponding peak heights is equal to the ratio of the component concentrations. Results:

Methane	**64.0**	**Ethane**	**2.2**
Nitrogen	**21.0**	**Ethylene**	**0.2**
Carbon Dioxide	**2.5**	**Propane**	**0.5**
Carbon Monoxide	**3.0**	**Hydrogen**	**6.6**

Figures for Carbon Monoxide and Ethylene were obtained by internal normalization, Hydrogen by the difference. If desired, Hydrogen may be determined by a separate analysis. A liquid partition column is used for analysis of the heavier ends. (X values represent step attenuations of recorder sensitivity.)



PEAK HEIGHT REPRODUCIBILITY

Sample Volume	**1 cc**
Column	**P-E type "D" (2 meters)**
Carrier Gas	**Helium**
Temperature	**25°C.**

Accuracy of gas analysis is dependent upon reproducibility of sample volume. The series of runs above demonstrate the unsurpassed sample metering precision of the Perkin-Elmer gas sampling system for the Models 154 and 154-B Vapor Fractometer.

New P-E Model 154-B Vapor Fractometer gives

PRECISE FUEL GAS ANALYSES AT LOW COST

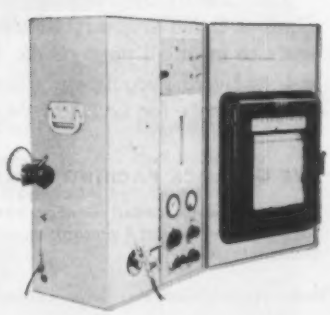
P-E's Model 154-B Vapor Fractometer, based on the principles of gas chromatography, will perform an analysis of a complex mixture of fuel gases—from hydrogen through the pentanes—in less than 60 minutes. Results equal or exceed those obtainable by expensive spectrometric methods, yet initial investment and operating costs are far less—by a factor of at least 10!

P-E feels that this powerful tool will find as broad applications in the chemical industry as any analytical method in existence today and will completely dominate the gas analysis field within the next five years.

If you're interested, write us for a preprint of "Fuel Gas Analysis by Vapor Fractometry (Gas Chromatography)," V. J. Coates and N. Brenner. Our sales engineers are ready to assist you in applying the Vapor Fractometer in your operation.

Perkin-Elmer CORPORATION

NORWALK, CONNECTICUT



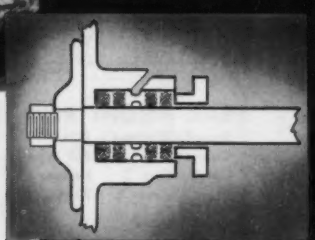
The Model 154-B Vapor Fractometer with recorder in matching cabinet (right) is priced at $2,385.00. Also available without recorder. Send for descriptive bulletin.

MORE OF
THE GARLOCK 2,000

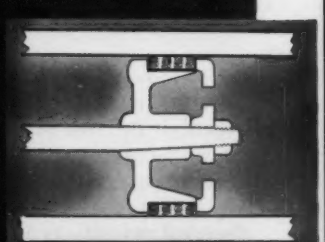
LATTICE-BRAID Packings of pure Teflon fiber for rotating shafts at high peripheral speeds . . . tough, chemically inert, yet resilient for positive sealing and cooler operation under extreme temperature and chemical exposure.

LATTICE-BRAID Asbestos Packing with Teflon impregnation, reduces friction, provides better seal with less gland pressure.

Wherever corrosion, contamination or torque is a problem on reciprocating applications or slow-turning valves CHEVRON† Packing made of Teflon is recommended.



Centrifugal pumps handling hot sulfuric acid and petroleum fractions leaked badly with ordinary packing. Also, new shaft sleeve required every few days. Teflon packing reduced leakage, and after several months service both packing and shaft were still in good condition.



Teflon packing rings on duplex pump handling 50% sodium hydroxide at 270 F. showed no sign of wear after 5 months. Formerly, packing lasted average of 30 days.

GARLOCK TEFLON*

Packings Reduce Process Shutdowns

Garlock LATTICE-BRAID† Packings of Teflon reduce maintenance, lower replacement costs, reduce wear on pistons and shafts, and increase productive capacity in countless pump applications where corrosive chemicals and severe operating conditions are encountered. The unique properties of Teflon (chemically inert, heat-resistant, low coefficient of friction, etc.) make it outstanding for use in chemical or petroleum process pump packings.

LATTICE-BRAID Packings of Teflon are another important part of "the Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals to meet all your needs. It's the only complete line. That's why you get *unbiased* recommendations from your Garlock representative. Call him, or write for LATTICE-BRAID Catalog AD 131.

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada. For information on other fluorocarbon plastic products contact United States Gasket Company, Plastics Division of Garlock.

*DuPont Company Trademark †Registered Trademarks

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Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints, Fluorocarbon Products

Put HARSHAW CATALYSTS to work for you

Harshaw Catalysts do a giant's work and Harshaw produces catalysts in giant quantities—carloads every week. A letter or phone call will put our 20 years' experience and acres of production and research facilities to work for you.

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to fit special process requirements

Hydroforming • Cyclization • Oxidation • Dehydrogenation • Dehydration • Desulphurization • Alkylation • Isomerization • Hydrogenation

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Aluminum Nitrate — Cobalt Nitrate
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Metallic Soaps (Cobalt, Manganese)
Nickel Carbonate — Nickel Formate
Nickel Nitrate — Nickel Sulfate
Sodium Methoxide — Zinc Nitrate

Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

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COMPANY

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HARSHAW CATALYSTS AVAILABLE IN THESE FORMS:

Tablets • Powders
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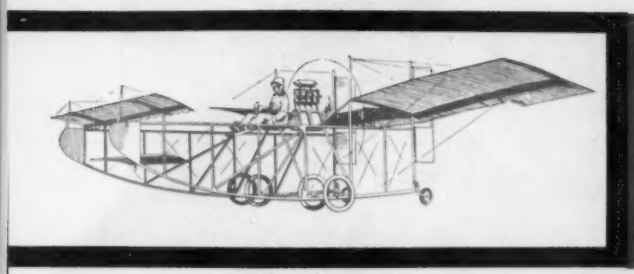
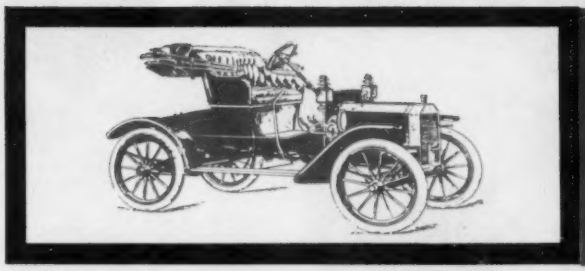
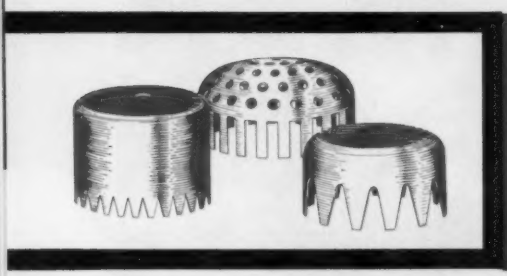
there's been

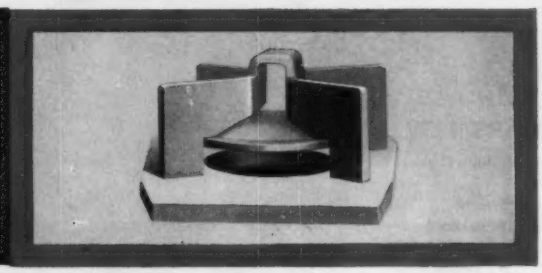


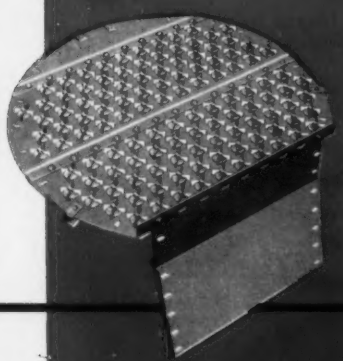
some changes made



in fractionating trays, too!







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Today's trend in progress is away from "horse-and-buggy" bubble trays to Koch's jet-age **FLEXITRAY** . . . and, for good reason!

With "Flexitray," the entire tray area is available for vapor-liquid breakout . . . no obstruction to liquid flow exists . . . vapor separates at lower velocities. "Flexitrays" remain cleaner – longer!

With its extreme flexibility and capacities, it is small wonder that major companies – looking for the best designed trays – have adopted "Flexitray" for more than 400 **NON-CAPTIVE** installations.

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KOCH ENGINEERING COMPANY, INC.

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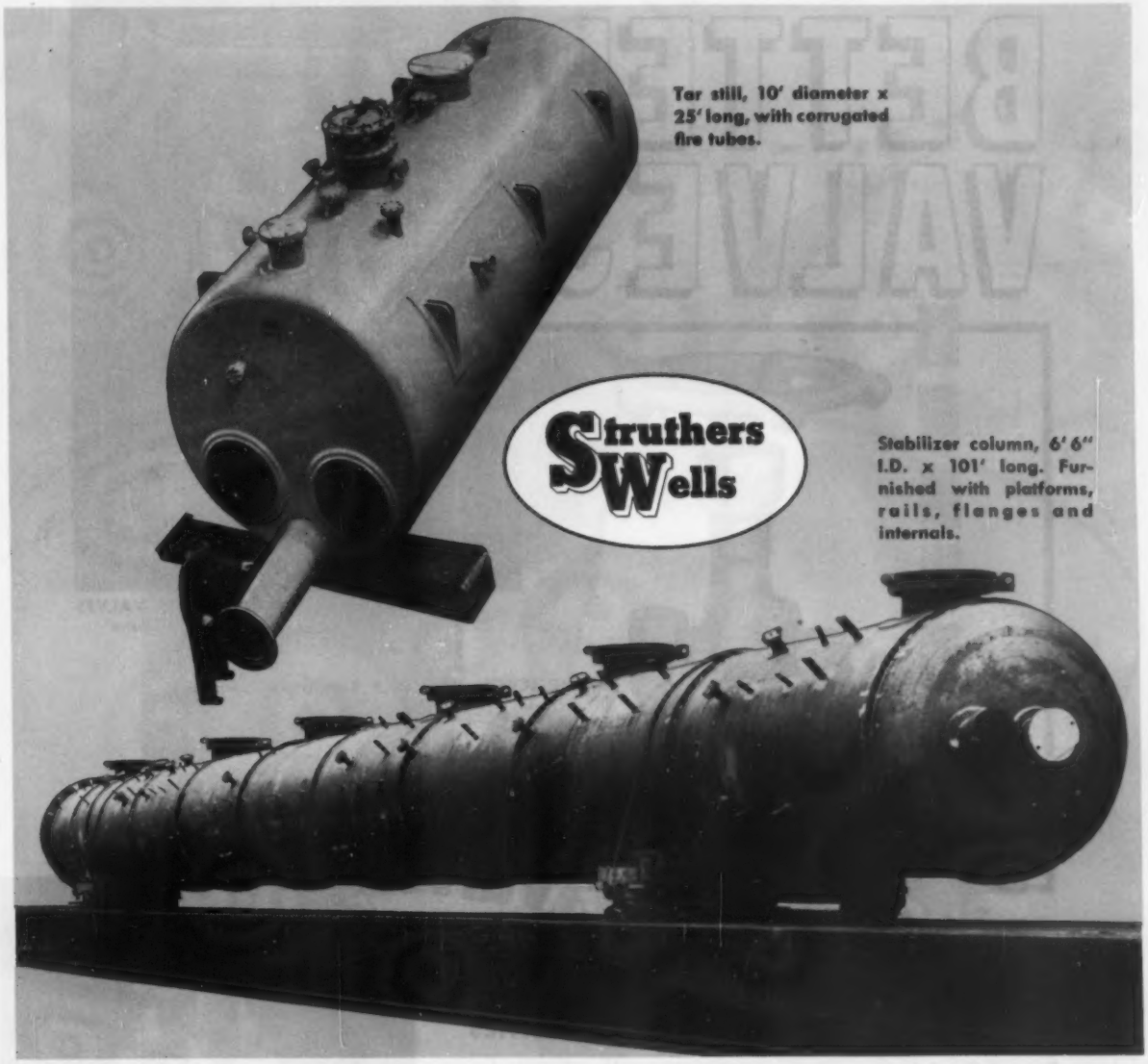
Tar still, 10' diameter x 25' long, with corrugated fire tubes.
Struthers Wells
Stabilizer column, 6' 6" I.D. x 101' long. Furnished with platforms, rails, flanges and internals.

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When you choose Struthers Wells as your process equipment fabricator, you place your requirements in the hands of highly skilled engineers, technicians, craftsmen and capable business men—whose aim is to provide you with highest quality equipment at lowest possible cost. All work is performed in our own plants—from production of forgings, weldments, patterns, etc., to machining, latest X-ray inspection, stress relieving and water quenching. Thus, you have undivided responsibility of control in the fabrication of equipment—in any metal or alloy—to meet all ASME or API Codes and your most exacting specifications. Backed by over 100 years of experience in the chemical and petroleum industries—you know equipment is *right* for your processing job when built by Struthers Wells.

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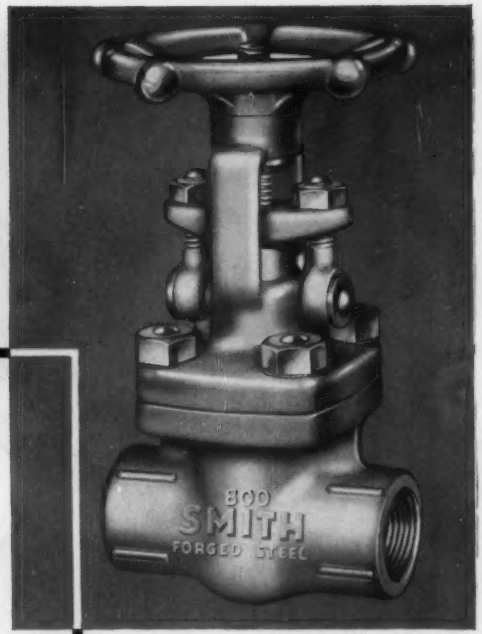

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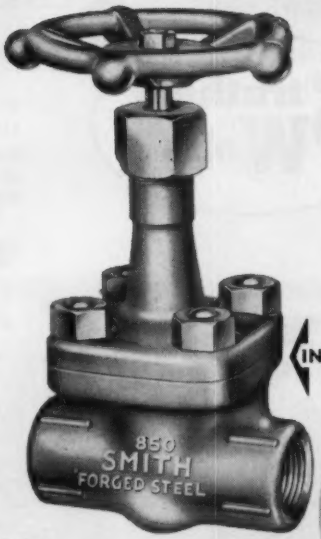
Sizes ¼" - 2", Inclusive



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Smith FORGED STEEL Valves

. . . *for* BETTER SERVICE

to the Refinery, Chemical, Petrochemical and allied Process Industries

Forged Steel for maximum strength and highest safety factor.

Bolted Bonnet plus **Flexitallic Gasket** for positive, tight bonnet joint.

Stem—375 Brinell—Rolled Threads (30% stronger than cut threads). Centerless ground stem shank, 6 to 8 micro finish, for unusually smooth operating stem and longer packing life.

Tear Drop designed gate, combined with accurately broached guides, insures perfectly controlled operation in high temperature, high pressure service.

500 Brinell Gate plus **Diamond Hard** chrome faced seats minimizes seizing, galling and abrasive wear.

These and other special features combine to make SMITH VALVES Stronger, Safer, Easier to Operate and Maintain . . . and what's really important, they *Cost No More* than other valves in the same rated pressure and temperature classifications.

FLANGED END GATE VALVES
• #150; #300; #600
Sizes ½" - 2" inclusive • A. S. A. Dimensions

NEW ENGLAND VALVE Corporation

P. O. BOX 1047 • WORCESTER, MASSACHUSETTS

West Coast Distributors: BETHLEHEM SUPPLY CO., LOS ANGELES, CALIFORNIA

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Why **DYNALOG*** *design is out front of all electronic potentiometers . . .*

IT GIVES STEPLESS, CONTINUOUS BALANCING!

Advance features to improve control of temperature, pressure, flow . . .

1. No periodic maintenance
2. No dry cell—no standardizing
3. No high-speed moving parts
4. No slidewire or galvanometer
5. *Stepless*, continuous balancing
6. Adaptable to narrow spans

FOXBORO
REG. U.S. PAT. OFF.
DYNALOG
ELECTRONIC INSTRUMENTS

Here's precision in motion . . . the smooth, continuous balancing action of a Dynalog Electronic Instrument! No slidewire with faltering step-by-step inaccuracies . . . no sliding or rubbing contacts. Instead, a simple, variable, radio-type capacitor and positive magnetic drive. It's friction-free, wear-free.

That's why Dynalogs respond almost instantly to the slightest change in a process variable, with a sensitivity of 1/100 of 1% of scale . . . accuracy of ¼ of 1% of scale. It's also the reason they're the maintenance man's dream. About all he does is supply ink and charts!

Dynalogs are used with any primary element—resistance, voltage, capacity, inductive. They perform with effortless accuracy, even on control and recording problems that conventional balancing-type instruments can't handle. For the complete story, write for Bulletin 20-10. **The Foxboro Company, 746 Norfolk Street, Foxboro, Mass., U.S.A.**

*Reg. U. S. Pat. Off.

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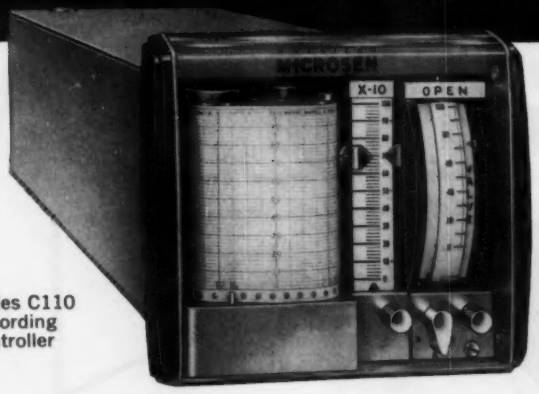
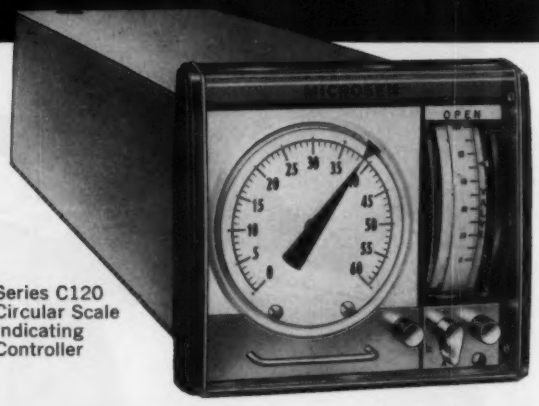
NEW TRANSISTORIZED ELECTRONIC CONTROLLERS
Interchangeable for complete versatility



Series C110
Recording
Controller



Series C120
Circular Scale
Indicating
Controller

The new 'American-Microsen' Series C100 Electronic Controllers can be interchanged at the panelboard in seconds. A recording controller to an indicating type . . . a proportional-action controller to proportional-plus-reset . . . slow reset to fast reset – any of these replacements is quickly made by pulling one unit out and plugging in the other.

The controller settings of the 'American-Microsen' System are all calibrated and repeatable. When a controller station is replaced, the proportional, reset and rate settings can be made in advance so the process is on control the instant the changeover is completed. No playing around to tune in the control.

When the process is on manual control during a replacement operation, the controller station stays in balance with the actual valve position. Thus the process can be changed back to automatic control without "bumping" or upset. A unique feature of the 'American-Microsen' System eliminates any "balance" or "seal" position between manual and automatic.

These are but a few of the many functional advantages of the new 'American-Microsen' Electronic Control System. Join the many satisfied users of this new approach to process control. Make certain you have the better control and simplified servicing so essential to higher product quality and greater operating economy. Arrange for a meeting with one of our sales engineers to determine the best equipment for your service. *Write for Bulletin RC100.*

Controller Performs These Functions

Measures input signal from transmitter and records or indicates in terms of the measured variable — pressure, temperature, flow, etc. (The Series C110 records on a 3-inch wide strip chart, the Series C120 indicates on a 4-inch diameter scale.)

Provides means of setting the desired value of the measured variable (set point) and compares actual value with desired value.

Transmits control signal, incorporating proportional, reset, and/or rate actions to operate final control element.

Provides means to operate control element manually with simple switch and manual knob.

Ultra-Modern Features Provided

All functions of recording (or indication), controlling (proportional, reset, and/or rate), and manual valve operation *in a single housing.*

Transistorized controller station for ultimate reliability and long service life.

Printed circuitry and miniaturized components for space-saving simplicity.

Plug-in units for complete interchangeability and ease of maintenance.

Ratio, cascade, and other similar control arrangements, using standard instruments.

Direct bumpless transfer from manual to automatic control with no intermediate position.

DC signals of 1.0 to 5.0 milliamperes for instantaneous distance transmission up to 30 miles.

Controllers are compatible with any unit of other manufacture using the standard 1 to 5 milliampere DC signal.

MANNING, MAXWELL & MOORE, INC.

MAXWELL MANNING M&M MOORE INC TRADE MARK

INDUSTRIAL CONTROLS DIVISION • STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC INSTRUMENTS FOR MEASUREMENT, TRANSMISSION AND CONTROL

Now... Local Availability on

Titeflex

Seal-Tight, Time-Saving

Quick-Seal Couplings

Titeflex Couplings are *leakproof* at *all* operating pressures—the higher the pressure the tighter the seal! Couple or uncouple in ONE second... without the aid of tools. Straight-through or single or double check-valve types. Allow free flow of *any* viscous material. Sizes from ¼" to 12" diameter. Made from a variety of metals and alloys to suit innumerable industrial applications.

Titeflex

Flexible Metal Hose

—the ideal "conveying mate" for Titeflex Couplings. Withstands high temperature and pressure stresses. Impervious to vibration and corrosive action.

Both these time-tested products are available for immediate shipment from distributors' stocks in most areas. Otherwise write, wire or telephone direct.

CALL YOUR LOCAL DISTRIBUTOR

Consult the yellow pages of your telephone directory

Your one source for both Hose and Couplings

Titeflex

TITEFLEX, INC., 600 HENDEE STREET, SPRINGFIELD 4, MASS.

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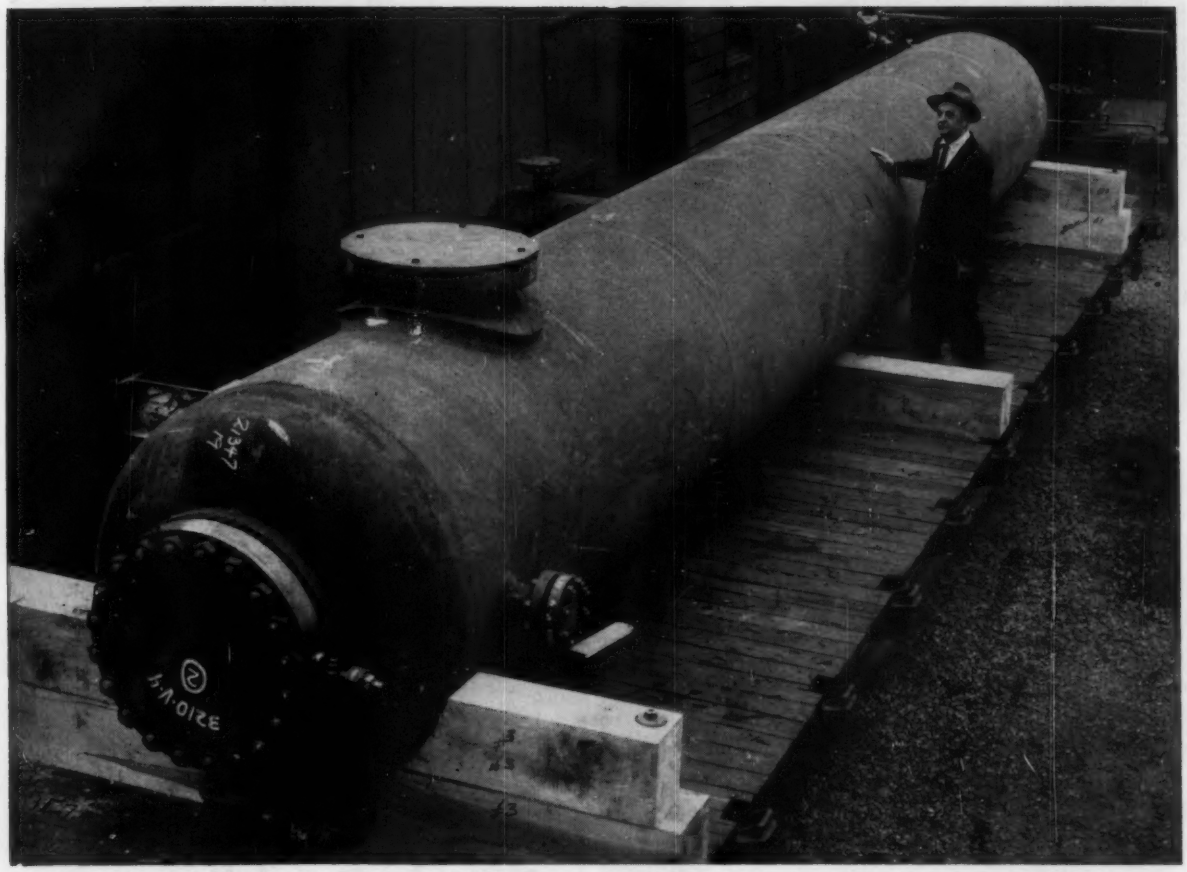


NEWPORT NEWS BUILT two 39′-7″ horizontal gas scrubbers, such as this, for J. F. Pritchard & Co. They were made of ASTM-A212 Grade B fire box steel, with structural mesh steel interiors.

Gas scrubber made of 2⅞" steel

Newport News builds almost any type of pressure vessel and other heavy process equipment

Here is one of two horizontal gas scrubbers recently built for an operating pressure of 1800 psi at 300°F.

Newport News made both vessels from fire box steel, 2⅞ inches in thickness. We formed and automatically welded this steel into sections having a diameter of only 4 feet.

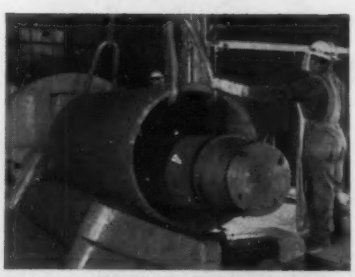
Rolling thick steel to this small diameter...no easy accomplishment, as you probably know . . . demonstrates the sort of jobs Newport News takes in stride.

Almost any type of heavy processing equipment is readily constructed by Newport News in a 225 acre plant comprising huge, fully equipped fabricating and machine shops, foundries, forge and die shops, heat treating and allied equipment as well as complete test facilities.

Newport News shop erection of fabricated units helps to speed assembly at your plant site.

Get a bid from Newport News on your present or future projects. Get the benefit of specialized production techniques. Look over the many ways in which Newport News can help you . . . write for "Facilities and Products", a very interesting booklet. It's yours for the asking.

ENGINEERS Desirable positions available at Newport News for Designers and Engineers in many categories. Address inquiries to Employment Manager.



ROLLING 2⅞" STEEL for gas scrubbers. The steel, in a hot condition, was formed on the heavy bending equipment shown here. It will cold roll mild steel up to 3 inches thick, and will hot roll any grade of steel up to a thickness of 5 inches.

Newport News Shipbuilding and Dry Dock Company
Newport News, Virginia

BUILT-IN FEATURES MAKE ORBIT VALVES SUPERIOR

STEEL DROP FORGINGS
Give body and bonnet maximum strength, no flaws, cracks or porous metal structures.

WELDED BONNET
Stronger construction, no bonnet gasket for exposure to corrosion.

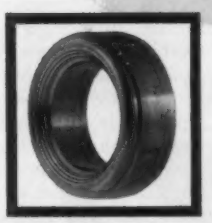
FRICTION-FREE SEATING
For easy operation—frequency of opening and closing immaterial.

SEATING
Segment of seating core is hard faced and ground for spherical seating to resilient body seat.

PATTERN AND SIZE RANGE
Full round opening available in six sizes, wide working pressure range, carbon or stainless trim, flanged or screw end. Venturi type—available in five sizes, carbon or stainless trim, flanged end only.

STEM PACKING
Plastic stem packing, teflon base, pliable, adjustable. Can add to or adjust while valve is in service and under pressure.

CLOSED POSITION



RESILIENT BODY SEAT: A type 416 stainless steel cage ring supports a resilient insert consisting of a laminae of type 430 stainless steel seating surfaces.

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ORBIT ASA CLASS VALVES FOR AMERICA'S MOST MODERN PLANTS

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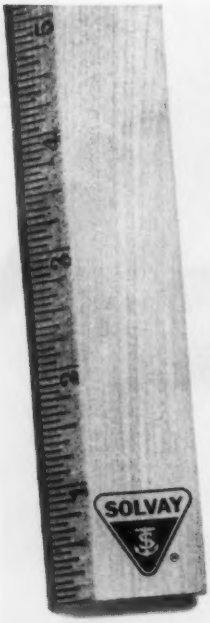

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Re Pump Packing

To The Editor

It is questionable whether the management of any plant, where there are many pumps or other equipment with stuffing boxes, has a good conception of what packing failures actually cost. The matter of packing replacement is insignificant compared with the costs due to interruptions in continuity of operation, loss of production, the necessity of having spare equipment, hazards, etc. I, therefore, thoroughly agree with the second paragraph of Mr. Woodhouse's article, "Centrifugal Pump Packings and Seals," in the January issue of PETROLEUM REFINER. But, from there on, we have to part company.

In all of the 12 figures presented the conventional stuffing box arrangement is shown and it has not been changed materially since centrifugal pumps were first built. The use of flushing and sealing liquids are palliatives and not cures and may actually introduce process problems. In all of these cases, after a period of operation, it will be found upon inspection that the packing next to the gland will be the most highly compressed and that the shaft shows evidence of wearing and scoring under this portion of the packing. This is why leakage is advocated but in many processes this can not be tolerated.

It would be possible in a long dissertation to describe what is wrong with each case but the answer is simply that the conventional method of applying packing is inherently incorrect. The remedy does not lie in changing the type of packing because, while some packing materials may do better than others, it is usually a matter of small degree. Packings initially are, or should be selected to meet the conditions of service.

By a proper analysis of the problem it should be possible to make a packing application which would have a service life of not less than six months in any service and with negligible attention. In other words, packing should not be the limiting factor in pump performance.

Walter Coopey,
Engineering Consultant
Charleston, W. Va.

Author's Comment

Mr. Coopey states that all 12 illustrations show conventional stuffing box arrangements. This is correct; it was intended to demonstrate contemporary standard practices.

He is also probably right in that almost any packing problem can be solved with proper analysis, but some applications can be very difficult so why run one's head against a brick wall when a simple solution—mechanical seals—may be at hand?

Harold Woodhouse
Dean Hill Pump Co.
Indianapolis, Ind.

Cites "Pitfalls"

To The Editor:

Several of my associates have called my attention to Dr. H. S. Myers' paper "V-L Equilibria for Naphthenes and Paraffins" in the March, 1957 PETROLEUM REFINER. The paper illustrates two pitfalls, both of which have appeared before in the distillation literature.

1. One is the statement "narrow-boiling naphthene-paraffin mixtures are essentially ideal" in the Summary. It depends upon what you mean by ideal. If you mean that the activity coefficient is close to unity, the statement is correct by definition. But if you mean that azeotropes are not formed, the statement is wrong. The point is that naphthene-paraffin azeotropes cannot form *unless* the mixture is narrow boiling. Our paper, "Cyclopentane and Neohexane in Petroleum," which you apparently missed. It shows three naphthene-paraffin azeotropes, including the cyclohexane-triptane azeotropes of Harrison and Berg, whose paper you cited without mentioning the azeotrope they found.

2. The other is the presumption that an equilibrium still is a good way to find close-boiling azeotropes. That is not its job, particularly at the ends of the composition range. Gross azeotropes show up clearly, especially at intermediate compositions where the boiling-point lowering is largest. But only with many plates instead of one, and at a high reflux ratio instead of none, can either the hydrocarbons or the experimenter clearly see azeotropes with lowerings of tenths of a degree.

Accordingly, Young could not possibly have seen the benzene-hexane azeotrope. Improved equilibrium stills and temperature measurements began to show it: Tongberg and Johnson weren't sure; Griswold and Ludwig thought so; you seem to doubt it. Our data on columns showed it clearly, and Lecat has almost proved it.

The benzene-heptane azeotrope is

For more data on advertised products, use Readers' Service Cards, last page.

HOW TO DOUBLE REFINERY RUNNING-TIME BY KEEPING CORROSION DOWN

After eight months' operation, with KONTOL on the job, an eastern refinery reported the following: corrosion in the overhead condenser was not even measurable . . . there was a 33⅓% increase in the heat transfer coefficient . . . tower tray corrosion was completely eliminated. And because of KONTOL's detergent action, running time in this typical depropanizer application was doubled.

Similar benefits are available to your refinery operation. Let your Kontol Service Engineer (The Man in the Red Car) show you *how.*

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TRETOLITE COMPANY
A DIVISION OF PETROLITE CORPORATION

369 Marshall Avenue, St. Louis 19, Missouri
5515 Telegraph Road, Los Angeles 22, California

KONTOL CORROSION PREVENTIVES ARE EFFECTIVE IN

Crude Stills • Depropanizers • Debutanizers • Depentanizers • Absorbers Stabilizers • Platformers • Reformers • Vacuum Towers • Alkylation Plants Coking Systems • Dewaxing Systems • Gas Recovery Systems • Cat Cracker Fractionators • Alkanolamine Sweeteners • Desulfurization Systems

SR-57-1

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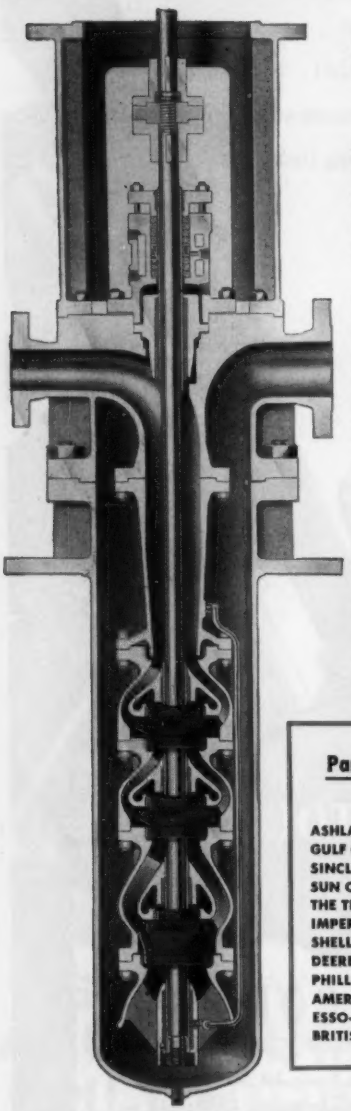
NEW! Bingham VCP VERTICAL PUMP FOR LOW NPSH



ALL WORKING PARTS ACCESSIBLE WITH BOTTOM DISMANTLING

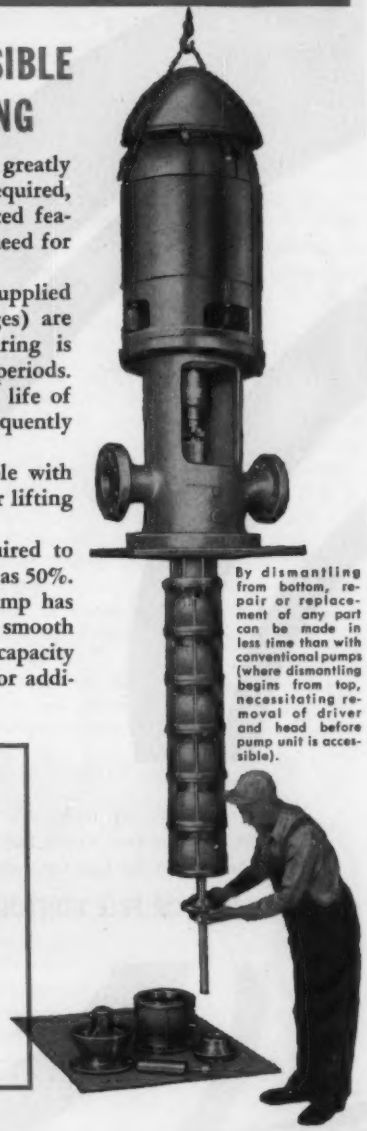
Besides bottom dismantling, which in itself greatly reduces maintenance time when attention is required, this new Bingham pump incorporates advanced features which minimize maintenance, reducing need for periodic inspection.

For example, all intermediate bearings (supplied of appropriate material for different pumpages) are forced-lubricated by pumpage. Bottom bearing is lubricated, even if pump runs dry for short periods. This *dependable* lubrication greatly prolongs life of bearings, which in conventional pumps are frequently the cause of maintenance shutdowns.

All working parts of pump easily accessible with bottom dismantling. One man can service after lifting pump from well.

Various operators estimate that time required to reach working parts has been reduced as much as 50%.

Wherever installed, the Bingham VCP Pump has given trouble-free service—plus unsurpassed smooth operation with no vibration. Available for any capacity or head. Write your nearest Bingham office for additional information.



By dismantling from bottom, repair or replacement of any part can be made in less time than with conventional pumps (where dismantling begins from top, necessitating removal of driver and head before pump unit is accessible).

Partial list of major oil companies with Bingham "VCP" Pumps in operation or on order:

ASHLAND OIL & REFINING CO.	LAKEHEAD PIPE LINE CO.
GULF OIL CORPORATION	CREOLE PETROLEUM CO.
SINCLAIR OIL & REFINING CO.	HUMBLE OIL COMPANY
SUN OIL COMPANY	STANDARD OIL CO. OF INDIANA
THE TEXAS COMPANY	CHEMICAL CONSTRUCTION CO.
IMPERIAL OIL CO., LTD.	CHAMPLIN REFINING CO.
SHELL OIL COMPANY	PACIFIC GAS & ELECTRIC CO.
DEERE & COMPANY	SOCONY MOBIL
PHILLIPS PETROLEUM CO.	AEROJET GENERAL CORP.
AMERICAN CYANAMIDE CO.	GREAT LAKES PIPE LINE CO.
ESSO-STANDARD OIL OF N. J.	KANEB PIPE LINE
BRITISH AMERICAN OIL CO., LTD.	BUCKEYE PIPE LINE CO.

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The Mail Box . . .

more difficult. The equilibrium still can't begin to see it, and without points near 99 percent benzene, does not even apply. Sieg had no points between 98 and 100 percent, and you had none between 96 and 100 percent. Brown and Ewald are probably on the right track; but even they cannot be sure whether an azeotrope is found at temperatures above 40°. Data on columns gave good evidence, but only a third technique can really settle the question.

Thus the facts hardly substantiate the implication in your paper that our contribution to the knowledge of naphthene-paraffin behavior consists of reporting two doubtful areas-paraffin azeotropes! I believe that our contributions amount to more than that.

R. F. Marschner
Standard Oil Co. (Ind.)
Whiting, Ind.

Author's Comment

1. Our use of the term "ideal solution behavior," refers, in the conventional sense, to solutions that obey Raoults Law. And where we say that narrow-boiling, naphthene-paraffin mixtures are essentially ideal, we mean that the activity coefficients are close to unity. Our entire discussion of ideality deals with values for activity coefficients. It is entirely possible for a close-boiling mixture to be essentially ideal and still form an azeotrope.

2. Now as to your second question on the use of an equilibrium still to find close-boiling azeotropes at the ends of the composition range, and when the boiling-point depression is but tenths of a degree. In our opinion, here is an application where the temperature-measuring technique has great value. Possibly we have not explained our procedure fully. This example will illustrate our method.

Since we received your letter, we have rechecked our original measurements on the benzene-heptane system. For this present work, we used a modified Cottrell boiling-point apparatus equipped with a vacuum jacket. And we measured boiling points with a platinum resistance-thermometer. First we measured the initial boiling-point of pure benzene. Then while the benzene was boiling, we slowly added heptane, a few drops at a time. If an azeotrope is present, the temperature must go down. But as our data in Table 1 indicates, the temperature slowly and steadily increased. This shows rather conclusively that the benzene-heptane system does not form an azeotrope.

TABLE 1
Boiling Points for Mixtures of Heptane and Benzene

Approximate Volume Percent Heptane	Boiling Point, C[1]	Barometric Pressure, Inches, Hg
0	79.625	29.53
0.33	79.63	29.53
0.66	79.64	29.53
1.5	79.67	29.53

[1] Measured with a Mueller Bridge and a platinum resistance thermometer.

Your paper reports the existence of benzene-heptane azeotrope at 99.3 percent benzene, with a boiling-point depression of 0.05 C. As you know, such an azeotrope will be practically impossible to approach in a fractionation column from the benzene end of the equilibrium diagram. And approaching it from the heptane end, as you were forced to do, in no way distinguishes between an azeotrope and a poor relative-volatility.

We have also rechecked our work on the benzene-hexane system, since receiving your letter. These data were obtained by the same methods described above for the benzene-heptane system. Table 2 shows the results. You'll notice that the maximum depression of boiling point that we have been able to find, is 0.01 C. This depression occurs in the range of 1.4 to about 6.7 percent benzene. Such a minor depression of boiling point may indicate the presence of a very weak azeotrope, or it may represent experimental error. But we have been unable to measure a boiling-point depression of 0.5 C as you have reported in your paper on hydrocarbon azeotropes of benzene. We understand that your work was done on a ternary mixture with methylcyclopentane. And we wonder how you were able to determine that the presence of methylcyclopentane did not affect the volatilities of the other two hydrocarbons.

You seem to take issue with the manner in which we have reviewed the results of previous investigators,

TABLE 2
Boiling Points for Mixtures of Hexane and Benzene

Approximate Volume Percent Benzene	Boiling Point, °C[1]	Barometric Pressure, Inches, Hg
0	68.07	29.33
0.35	68.07	29.33
1.06	68.07	29.33
1.4	68.06	29.33
1.75	68.065	29.33
2.1	68.06	29.33
2.8	68.06	29.33
4.1	28.06	29.33
4.8	68.07	29.33
5.4	68.055	29.33
6.7	68.065	29.33
7.9	68.08	29.33
9.1	68.095	29.33
9.7	68.10	29.33
10.8	68.13	29.33

[1] Measured with a Mueller Bridge and a platinum resistance thermometer.

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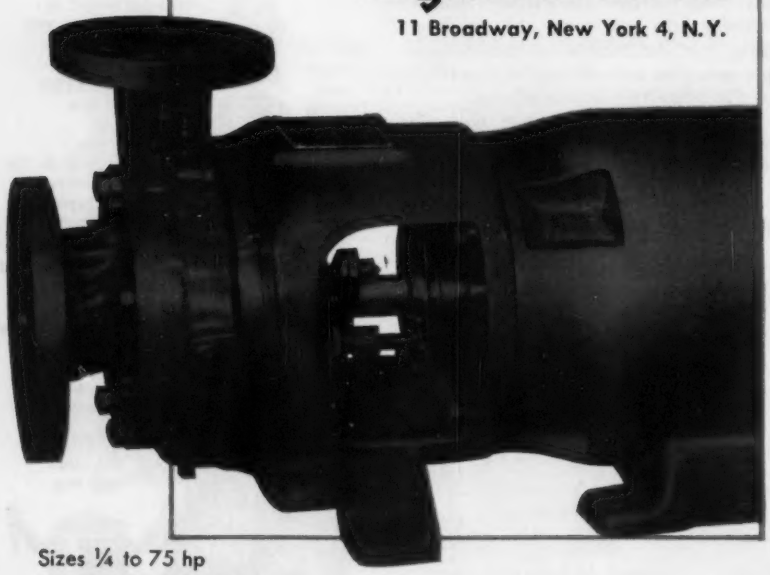

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The Mail Box . . .

particularly the results of your own work. We merely pointed out that there is considerable disagreement in the literature concerning whether or not benzene forms azeotropes with hexane and heptane. Our original work, within accuracy of our measurements, indicated that it does not.

Our latest studies, shown in Tables 1 and 2, substantiate our earlier results. We feel, however, that the question may never be fully settled. It is entirely possible, for example, that benzene and heptane might form an azeotrope at, say, 99.5 percent benzene with a boiling-point depression of 0.001 C. And benzene and hexane may azeotrope with a depression of around 0.01 C. As you know, proof of such azeotropes is difficult, either by our technique or by a fractionation column. And for design purposes, at least, there is little advantage in differentiating between an azeotrope of this type and a very poor relative volatility.

H. S. Myers,
Research Engineer, C F Braun & Co.

Marschner Rejoinder

Dear Dr. Myers:

You were concerned particularly with column design; we were more concerned with the nature of hydrocarbon liquids. Whether we interpret information in exactly the same way is less important than making good use of it.

Your explanation that close-boiling mixtures can have activity coefficients near unity and still form azeotropes answers my first comment. I fully agree. Your term "essentially ideal" then simply meant that activity coefficients were near unity but not so near as to exclude possible azeotrope formation, which is, of course, direct evidence for nonideality, however slight.

Your Table 2 is probably the best temperature study ever made of benzene-hexane at compositions below 10 percent benzene in one-plate apparatus. Taken alone, the boiling-point depression might look like experimental error, but taken in combination with our work on separation in columns, I think it is confirmation that an azeotrope exists.

The amount of depression is puzzling. I hold no brief for our value of 0.5°, for our thermometer was accurate to only 0.2°, although the precision was perhaps 0.1°, and we corrected for pressure rather than holding it constant as you did. I would expect a lowering much larger than 0.01°, however, for 100-plate columns concentrate the azeotrope from excess

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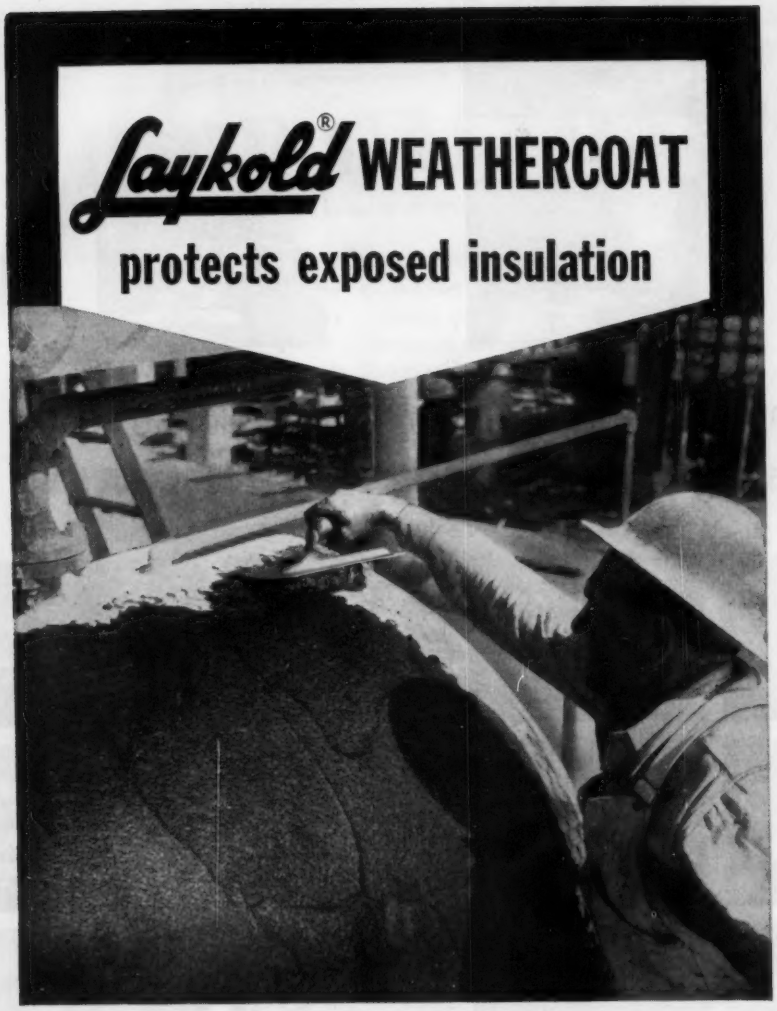

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The Mail Box . . .

hexane easily.

Our columns gave evidence for the azeotrope in the presence of either excess hexane or excess benzene, whether methylcyclopentane was present or absent. We therefore did not measure the small effect that methylcyclopentane may well have. We certainly agree with your thought that it is a "weak" azeotrope at best.

Your Table 1 shows, as our column work did, that benzene-heptane is an order of magnitude more difficult. If 1 ml. of heptane is fractionated with 500 ml. benzene through a 90-plate column at 100:1 reflux ratio, the refractive index drifts upwards and no heptane is found in the residue. Yet your new data, the only work that has been done in an equilibrium still below 1 percent heptane, can find no temperature depression. Both facts look convincing, but neither technique is designed to determine whether benzene-heptane azeotrope exists or not.

My concern about the references to our work in your paper was not polemic. It was only because the way they were cited or not cited happened to give a misleading picture. The title of the paper implied that the main subject was paraffin-naphthene systems; that azeotropes sometimes can and do occur was not mentioned. Under the incidental subject of arene systems, the paper suggested that the evidence stood 3:2 against benzene-hexane and 3:1 against benzene-heptane; that arene azeotropes are uncommon was implied. Our work, carried out by different methods, offers quite different emphasis. Unlike arenes, which form azeotropes with all paraffins and naphthenes that boil nearby, paraffins and naphthenes form azeotropes only when the boiling points are so close that the abnormality can be ignored for most practical purposes.

R. F. Marschner

Unifiner-Catformer

To The Editor:

In the April 1957 issue of PETROLEUM REFINER, Page 3, under "A Quick Look," the catalytic reformer which the Dorchester Corp. is building at their White Deer gasoline plant has been erroneously called a "Unifiner-Platformer." This sort of error is of serious concern to us. I request that a correction to this error be printed using the name Unifiner-Catformer as it correctly appears in the article which begins on Page 146.

J. A. Nevison,
Philadelphia — Atlantic Refining Co.

For more data on advertised products, use Readers' Service Cards, last page.

PHOTO COURTESY OF C F BRAUN & CO
ENGINEERS AND CONSTRUCTORS

PACIFIC PUMPS INC was selected to supply practically 100% of TIDEWATER'S centrifugal process pumps for their new DELAWARE REFINERY

Pacific's world-wide reputation for engineering pumps with outstanding performance and service records was further evidenced by Tidewater's choice. We are justly proud of this opportunity to put more Pacific pumps to work for Tidewater at Delaware as we have at their Avon, California refinery. It is our feeling that our excellent pump service engineering staff (always available when needed, anywhere, anytime) also influenced their decision. Whatever your pumping requirements—it will pay you to consult Pacific.

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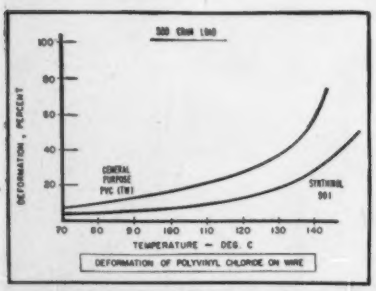
Troubled with wiring failures in your refinery?

If so, consider the record being established by Rome Synthinol 901, a special 90° PVC compound for wire insulation and sheathing. It has helped to solve an impressive list of difficult wiring problems.

Developed by Rome Cable's laboratory and first introduced in 1949, Rome Synthinol 901 has proved by test and actual use to be superior to conventional PVC compounds in the following ways:

a. Suitable for continuous operation at higher temperature (90°C).
b. More stable under severe heat cycling.
c. Suitable for continuous immersion in hot transformer oil.
d. Superior resistance to chemicals and solvents.
e. Greater resistance to heat deformation.



Graph shows heat deformation vs. temperature, and compares Synthinol 901 with conventional PVC compounds. Test run in accordance with Underwriters' Laboratories standard procedure, except for temperature.

The practical value of this compound can best be illustrated by describing a number of actual case histories.

(1) Oil refinery, industrial and chemical plant wiring.

Plant and oil refinery engineers have long used conventional PVC insulations for plant wiring with good results, but too often heat deformation problems arose in warm locations. Since Rome Synthinol 901's superior deformation resistance suggested that it might be the answer to this problem, it was tried and soon became widely used because of its much better service record.

Synthinol 901 also proved to be far superior to conventional materials for chemical plant wiring where the corrosive action of chemicals and solvents has always been a tough problem. Although polyvinyl chlorides as a class have inherently better resistance to chemicals and solvents than many other materials, some engineers desired even further improvement. One user decided to test a number of samples over a long period by immersing them in various concentrations of acetone, different alkalis, and butyric, propionic, and acetic acids. The results of this careful evaluation showed clearly that, when exposed to these chemicals, Synthinol 901 would last longer than any other PVC tested.

(2) Oil-filled transformers.

Transformer engineers have long sought a cable construction to replace varnished cambric-insulated cable for leads in oil-filled transformers. These leads connect transformer windings and bushings and are constantly immersed in hot oil. One transformer manufacturer, encouraged by successful experience with Synthinol 901 on other applications, undertook a comprehensive study of the possible usefulness of this insulation in lieu of varnished cambric for high-voltage transformer leads. This study extended over a several-year period and proved to those engineers involved that there were at least four reasons for standardizing on Synthinol 901 for this application:

a. There was less sludge in the oil than when VC insulation was used.
b. There was no harmful degradation of the electrical properties of the oil.
c. Conductors insulated with Synthinol 901 ran cooler, permitting a 7% increase in lead cable current rating.
d. The use of Synthinol 901 in lieu of VC would permit substantial dollar savings.

(3) Coil leads.

Many manufacturers of small coils for relays, small transformers, small motors, and electronic components have tried to use PVC insulated lead wires for many years. Typically, these leads are crimped or soldered to the ends of the coil; and the whole coil is then impregnated with varnish or wax and baked as long as 16 hours at temperatures as high as 150° C. The varnish used may be asphaltic, phenolic, alkyd, etc.; and the wax may be paraffin, beeswax, carnauba, or another kind.

PVC insulated lead wires frequently produced serious production problems because of the insulation's tendency to shrink, crack, and stiffen during the impregnation and subsequent baking period. Synthinol 901 was substituted in place of the ordinary PVC insulation and, after nearly eight years of wide usage, not a single case of shrinkage, cracking, or stiffening of insulation involving Synthinol 901 has been brought to our attention.

These case histories describe just a few of the applications for which Rome's Synthinol 901 has proved especially effective. Perhaps they will suggest other applications in your own area which might also be better handled with Rome Synthinol 901 instead of a conventional PVC compound. If you have a wire or cable problem that might be solved with Rome Synthinol 901, why don't you get in touch with us? Contact your nearest Rome Cable representative for more information—or write to Department 320, Rome Cable Corporation, Rome, N. Y.

ROME CABLE
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A Quick Look at the Industry THIS MONTH

The Moon and Avfuel— A Challenge to Refiners . . .

Only one thing is certain in today's jet fuel picture—future planes will require cleaner, dryer fuels with certain specifications as to volatility, viscosity and low freeze point. Such fuels are yet to be adopted. This lack of a specific long-range goal is posing knotty problems for refiners, i.e., what types of fuels should refiners plan to make—and how much?

Debate continues to center around two types of jet fuel: Kerosine and broad-cut JP4. Prediction is that major portion of future demand will be in JP4 category.

In avgas, trend quality-wise is toward ever-increasing portions of grade 115/145, a mixed alkylate blending agent, plus tetraethyl lead.

Race to the moon—and other planets—is raising similar questions: To what extent will solid and liquid fuels power rockets of the future? Heavy stakes are being bet on both types.

Currently, liquid fuels with oxidizers are leading the pack for inter-continental and intermediate range missiles. Advantage: Have highest thrust-weight ratio to date. Drawback: Require intricately complex working parts in huge engines.

Solid fuels (Thiokol's synthetic rubber compounds, nitro-polymers) are making strong entry in the field. Advantages: Simpler and safer to handle. Drawbacks: So far, they do not have power of liquid fuels, do not burn at constant rate.

—•—

Refining Outlook . . .

Summer demand will level off excess gasoline stocks created by winter lag, re-opening of Suez. Kerosine, distillates and residuals continue to exceed market conditions. Reduction of stocks are in order—and may be expected shortly.

Loans for refinery expansion remain tight, with no let up in sight for at least six months. Reason: Banks are being deluged with credit demands far in excess of resources. Economic forces which created this situation are expected to continue.

Gasoline demand will continue to spiral upward in '57, continuing trend that set new all-time consumption record last year. Total: 1.33 billion barrels—31.7 million barrels more than in '55.

—•—

Petrochemical Profits Show Downward Trend . . .

Greater production and stiffer competition in certain petrochemical fields is cutting into profit margins. In first quarter '57 report to stockholders, Koppers Co. says: "Principal cause of lower profits for the year is softening in prices of styrene monomer, polyethylene and polystyrene. High pressure polyethylene dropped six cents per pound in past 12 months. Styrene will be selling almost four cents a pound less by July. Price trend is reflected throughout plastics industry . . . lower prices will create reduction in '57 of $3-4 million in Kopper's before-tax income."

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Postings on Octane Race . . .

Ethyl Corp.'s new rating report for stepped-up premium grades showed national range of 100.3 to 101.8 octanes for May, compared with April's 100 to 101.6. Premium averaged 98 octanes in 57 marketing areas, 0.3 higher than April, while regular averaged 90.8 octane, 0.2 over April.

Tidewater and Standard of Indiana are introducing new premium gasolines. Indiana Standard is replacing its old premium with product that contains low-cost phosphorous compound, said to be key to combustion control. Company says additive curbs surface ignition and spark plug fouling from normal carbon deposit build-up.

Fast Thinking Brains . . . Fantastic increases in computer speeds may be in the offing shortly. Speeds in the millimicrosecond (one billionth of a second) range are now topic of tentative exploration. If reached, these speeds would be two-three times faster than present machines are capable of producing.

—•—

Gas Turbine vs. Free Piston Engines . . . Though still years away from production lines, gas turbines show promise for ships, truck and passenger car use, while free piston engine has great potential for farm tractors, industrial engines and other low speed, high torque uses.

Biggest obstacle to free piston use in cars: Its size increases disproportionately in the high horsepower ranges. Gas turbine also has several rough spots yet to be smoothed out: Fuel consumption is high—operating temperatures require special costly heat-resistant metals—acceleration lag is too pronounced to be tolerated in comparison with present engine standards.

—•—

Engineers Say "No" to Unionization . . . Minneapolis Honeywell's professional employes have turned thumbs down on bids of Engineers and Scientists of America and United Auto Workers Local 701 to serve as their bargaining agents. Vote was a blow to ESA's concerted efforts to expand and to UAW's recent bid to have professionals join their forces.

—•—

Oil in Washington . . . Natural gas producers face regulation as public utility for some time to come. There will be no action on Harris Bill in this session of Congress. It is being "amended" to death.

Prediction is that 27.5 depletion provision is in no danger of reduction by Congress this year. Retiring Treasury Secretary Humphrey, his replacement Robert B. Anderson and President Eisenhower have all indicated publicly they have no objection to maintaining "status quo."

Pessure is mounting to put stiffer curbs on imports. Federal action is expected shortly. Reason: Administration officials have been advised that increased imports threaten to drive small independent wildcatters out of business, thus posing "threat to vital natural resources in time of war."

—•—

Plastics Prodigy Shows Promise . . . A new term—polycarbonates—is stirring up great deal of interest in petrochemical circles. The recently developed family of thermoplastic resins offers a combination of toughness, impact strength, heat resistance and dimensional stability. Result: Polycarbonates may soon be giving stiff competition to nylon and fluorocarbons in some applications.

Polycarbonate developers, General Electric and Bayer (Germany), say they have already synthesized 20-50 different polycarbonates—and many more are yet to come.

—•—

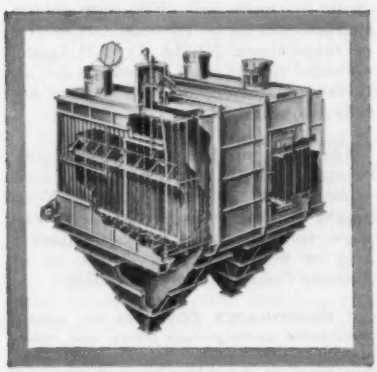
New Horizons for Synthetic Rubber . . . Prediction: Within 10 years natural rubber will supply less than half the world's rubber needs. Reason: There is not enough natural rubber in sight to take care of growing demand. Natural rubber production cannot increase more than 2½ percent annually through 1965, while world demand will be increasing about 5 percent annually, compounded.

Synthetic rubber comprised 37.6 percent of world rubber consumption in '56, while in the U. S. more than 60 percent of rubber used was man-made.

—•—

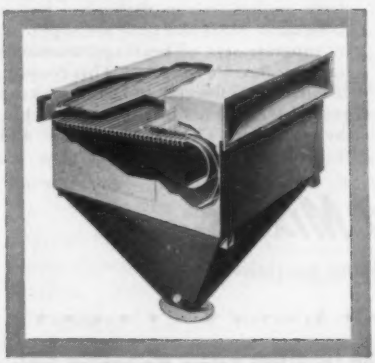
Atoms in the Refinery . . . Esso Research and Engineering has produced gasoline from heavier oil stocks and refinery gases in small-scale nuclear energy tests. Tests, using radiation sources even more potent than before, were made in "swimming pool" reactor at Battelle Memorial Institute center, Columbus, Ohio.

How Buell's exclusive Shave-off pays off in extra dust collection efficiency



Buell SF Electric Precipitator also delivers extra dust collection efficiency, due to unique Spiralectrodes and Continuous Cycle Rapping.

Proper proportioning, side entry of dust-laden gases, add even more extra efficiency and long, maintenance-free life to Buell Cyclones. Large diameter design eliminates bridging and clogging, keeps efficiency high under varying loads.



Buell Low Resistance Fly Ash Collector combines top efficiency with low draft loss, for either natural or mechanical draft installations.

For more specific data about Buell's *extra efficiency*, write Dept. 21-F.
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MECHANICAL ELECTRICAL *Experts at delivering Extra Efficiency in* **DUST COLLECTION SYSTEMS**

For more data on advertised products, use Readers' Service Cards, last page.

Can you answer these **5 cost-cutting questions** *about big-tank mixers?*

If you can, you know how to get most efficient mixing for your company

1 How can I get mixer shaft seals that meet any operating conditions? It's easy—just standardize on LIGHTNIN Mixers for your big tanks. Get your choice of *four* standard stuffing boxes, or a wide choice of rotary mechanical seals. With LIGHTNINS, you're sure of getting the *right* shaft seal for years of trouble-free mixing or blending.

2 What's the advantage of LIGHTNIN cartridge-type rotary mechanical shaft seal? No stuffing box to repack or maintain. You can replace the LIGHTNIN Seal in minutes, if it ever wears out. No need to drain the tank or dismantle the mixer; no need for special skill—you're back in operation fast! Many users of the LIGHTNIN Seal are saving thousands of dollars per year with this exclusive feature.

3 What's the quickest, simplest way to shut off tank contents before repacking, or changing a seal? The LIGHTNIN way! Easy-to-get-at handles are out in the open, always accessible. A few turns provide quick, positive shutoff of tank contents from mixer. Only LIGHTNIN gives you this time-saving advantage.

4 What mixer gives me most protection of the drive gears? LIGHTNIN again! The mixer shaft, in LIGHTNIN gear drive models, passes through a hollow drive quill. Shaft and quill are supported by separate sets of bearings, connected only by a flexible coupling. This coupling cushions shaft flexures and strains—keeps excessive shock loads from ever reaching the gearing. This construction adds years of safe operating life.

5 What's a good way to keep motor safe from dirt, dust, excessive moisture? Put the motor on top! This design, exclusive with LIGHTNIN, not only protects the motor; it centers weight closer to tank wall. You can choose standard foot-mounted motors, as shown, or round-frame NEMA Type P flange-mounted motors in all enclosures and all current characteristics. All motors are fully guaranteed.

These are just five of the engineering reasons why you get better, lower-cost mixing with LIGHTNIN Mixers. Your nearby LIGHTNIN representative can show you more. For quick, competent help on fluid mixing, look him up in Refinery Catalog. Or write us direct.

CUT MAINTENANCE COST with this quickly replaceable cartridge-type rotary seal, available on all LIGHTNIN Side Entering Mixers. Seal takes the place of a stuffing box; ends repacking for good; runs for years without adjustment; *slides off* for fast, easy replacement.

Lightnin® Mixers

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Check, clip, and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 164-f Mt. Read Blvd., Rochester 11, N. Y.

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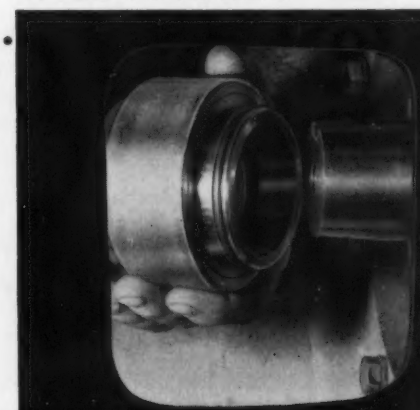

Standardization Can Reduce Costs

EQUIPMENT COSTS, including replacement parts, are tightly enmeshed in the inflationary spiral. Periodically suppliers are forced to boost their equipment prices to keep up with increasing costs. Refiners' capital and operating expenditures are going up accordingly.

How can these mounting equipment costs be curbed? One answer is to expand dimensional standards beyond their present coverage. By insisting on such standards the refining industry can improve tremendously on interchangeability of equipment. This, in turn, will reduce inventory of spare parts stock. And, will lower future capital expenditures.

The advantages of expanding the use of dimensional standards go far beyond merely reducing costs. They will cut down on the work load of engineering departments. They will reduce the multitude of designs and production schedules which equipment manufacturers are compelled to maintain.

Present Status. Dimensional standards have been around a long time. Take a look at valves, for instance. There was a time when every designer had to choose from a variety of face-to-face dimensions. Then something happened. A few of the large users asked the manufacturers to set some *standard* face-to-face dimensions. To the consumers' surprise, the manufacturers took the bull by the horns and, through the cooperation of industry and the American Standards Association, established an industry-wide set of valve standards. The savings in replacement costs on valves alone have more than justified the effort put into their standardization.

The same *could* be true for other pieces of refining equipment. But, the industry has a long way to go before a complete set of dimensional standards becomes a reality.

If so much can be done for valves, why can't the same savings be made by standardizing pump dimensions? For example, one plant has more than 1200 pumps in operation. There are 400 different types and styles, none of which are interchangeable, and none of which vary over 5 gpm, or more than several feet of head. Standardization would save this plant countless thousands of dollars over the years.

Another company analyzed nine pumps in the capacity range of 5-500 gpm. The study revealed the astonishing sum of 16 different shaft diameters, sized in increments from ⅛ inch to 1 inch, and even in decimals.

What difference does it make if the pump shafts are of different sizes? Could not the difference be handled satisfactorily in the coupling? The statement of a seal manufacturer should point out the fallacy of this "easy" way out. He says: "If standards could be established on shaft diameters where the shaft goes through the stuffing box, seal prices could be reduced by 50 percent."

Pump Design. Let's see what engineering problems are encountered as a result of multiplicity in pump design. Prior to the preparation of piping and foundation drawings, the designer must obtain certified prints of the pump that is specified. He must get the certified prints, see that field notes are made on the dimensions required, check piping and electrical connections—and accomplish the entire construction operation with a dozen construction foremen seeking information.

Would not it be a lot easier if the design engineer *knew* in advance about the pump's dimensions so that he could "flange-up" all of the piping and foundation drawings without having to get certified drawings?

Replacement and Maintenance Costs. Aside from design problems, another important factor is the money spent on replacement and maintenance. It is estimated that these costs amount to 50 percent of the initial cost of the pump, annually. At first glance it would appear that maintenance costs are becoming far too high. However, the real villain is lack of standardization. Here are the reasons:

- Everything mechanical requires a certain amount of repair and downtime. But, because there exists a lack of interchangeability, a plant's inventory soars.
- Engineering time increases as a result of varying basic dimensions such as base plates on pumps.
- Maintenance costs increase because of the variety of types and sizes involved with each piece of equipment. In the case of pumps, foundations must be knocked out and replaced, piping changed and electrical conduit relocated when one manufacturer's pump is replaced with another.

If the need for a complete set of pump dimensional standards is so great, why haven't they been established? Mainly because the refining industry can't

NEW DEALER MEETING DEMONSTRATION—For a vivid demonstration of how carburetor icing causes stalling and how it can be prevented with DMF, ask our representative to show you the new single-cylinder engine assembly.

The new unit consists of a small ice tower and a 1.6-horsepower engine connected by a glass tube manifold. When ordinary gasolines are drawn through the tube, ice forms on a little metal valve and causes the engine to stall. But the addition of Du Pont DMF to the gasoline prevents any buildup of ice.

To convince your dealers and customers of the advantages of your new *no-stall* gasoline with DMF, we will be glad to help you build your own demonstration units.

Experiments reveal facts about carburetor icing

Recent experiments indicate that stalling due to carburetor icing occurs even in 55-degree weather. Moreover, they prove that Du Pont DMF (dimethyl formamide) provides the motorist with protection against this type of hazard and annoyance.

Stall-prevention is especially important in many cars having power brakes and power steering—both of which are less effective when the car-engine stops.

Dimethyl formamide proved effective in low concentrations

Its practical use concentration turned out to be under 0.10 volume per cent—in other words, less than three milliliters per gallon!

Long stalling season

Conditions under which your customers' cars can stall also became clearer. The "refrigerant" action of gasoline can lower the temperature of carburetor parts to freezing even on comparatively warm days. Generally speaking, temperatures from 22 to 55 degrees Fahrenheit can lead to carburetor icing when humidity is 65 per cent or higher.

Expanding de-icer market

Motorists are showing an ever-increasing interest in gasoline performance. By anticipating a greater demand next fall for gasolines which contain anti-stalling agents, you can increase the number of your cold-weather customers. Now is the time to plan for the day when temperatures begin dropping below 55 and carburetor icing begins.

Economy and reduced storage

DMF offers two important benefits—economy and minimum storage-space requirement. The low volume concentration that's needed represents a real saving in freight and blending costs. And, because of the high efficiency of Du Pont DMF, and the low concentration required, little storage space is necessary.

A Du Pont Petroleum Chemicals Division representative will be glad to give you more detailed information on DMF. You can contact him at any of our sales offices listed at right.

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seem to agree on what a workable set of standards should contain.

Nevertheless, here is the way one enterprising engineer put standards to work in his plant. Instead of selecting the most efficient pump for each of the individual services, he selected several different pipe sizes. The pump coming nearest to the service requirements was selected. Using this method, the number of different pump sizes required was reduced by two-thirds of the amount required under the optimum selection system. And, a saving of $50 per pump was realized in the original purchase price of the pumps. In addition to the first cost saving, there was a material saving in spare parts investment and warehousing costs. The pump efficiency was lowered in some cases, but the difference was too small to consider.

If this idea can work in one plant, why can't it work in all of them? Why wouldn't a set of dimensional standards cut costs even further? And pumps are just one example. There are many other pieces of equipment that are just as badly in need of standardization.

Look around your plant. It won't take long to see where equipment costs can be cut through dimensional standards. Then, make a special effort to support your societies' efforts—and use the standards they have prepared.

The result will be dollar savings for your company.

Smog Blame Is Confirmed

SILENT SAM, the spectroscopic smog detective, has confirmed what refiners have said all along about the Los Angeles smog—that auto exhaust gases are the principal problem. Scientists from Franklin Institute, who perfected the measuring instrument based on the technique of long-path spectroscopy, explained latest studies at May API meeting. They concluded:

- That the field studies in the Los Angeles area by the mobil counterpart of the original "Silent Sam" have confirmed virtually every detail of laboratory studies on air pollution.
- That the mysterious "Compound X" is a new organic nitrogen compound, peroxyacyl nitrite.
- That this compound as was suspected is a major culprit in the formation of smog, even though concentrations are very low.
- That exhaust gases from automobiles are the principal offenders in the formation of smog in the high-traffic Los Angeles area.

The original "Silent Sam" was developed by Scott and others at the Franklin Institute some time ago. It was last August when a second apparatus was housed in a trailer and moved to the West Coast to do its detecting. Its main purpose was to verify the existence and concentration of "Compound X." It was found that this compound formed rapidly under certain conditions and served as an intermediate component in the formation of smog. Thus, its confirmation may be termed the missing link in atmospheric knowledge.

Besides confirming the mysterious compound, these studies also showed a specific relationship between exhaust gases from autos, the amount of traffic going on, and air pollution.

PETROLEUM REFINER congratulates the Franklin Institute and API (who sponsored the studies) for this important step towards smog understanding.

Refinery Output Cutbacks Needed

RECENT WEEKS HAVE SEEN the nation's refiners lower their operations slightly in a move to better supply this period of relatively low demand for petroleum products. But the cutback has not been sufficient to keep supplies from piling up. Current oil demand has dropped more than the expected normal seasonal slackening that comes during the changeover from heating oil's use to heavy motoring's consumption of gasoline. Use of the industry's products during recent weeks has actually slipped behind consumption during the same period of last year. One of the principal causes of this lagging has been the weather. It has been the type of weather that does no good for the oil industry, as wind and rain storms do not necessitate firing up the furnaces, but do help to keep the family autos in the garage.

Total demand for the four principal refined products during the four weeks ended May 24, lagged 1.6 percent behind consumption during the same period of 1956, while the first quarter of 1957 saw consumption of these products top last year's by more than 5 percent. During this recent four-weeks period, production of the four products amounted to 3 percent more than was produced a year before. This, coupled with lower consumption rates, caused stocks to swell.

Inventories of the four principal products gained 17½ million barrels during this four-weeks period, and instead of being in excess of last year's volume by 9.8 percent, as they were at the beginning of the period, they had, in 28 days, jumped to a point 12.4 percent higher.

Not only was lower demand responsible for stocks buildup, but the industry, while running 1.6 percent more crude to its refinery stills, was taking a bigger cut of the four products. Gasoline yield during the period amounted to 43.1 percent, while only 42.2 percent of all crude processed was made into gasoline during last year's four weeks. Distillate fuel oils yield averaged 22.8 percent, against 21.6 percent a year earlier. The other products, kerosine and residual fuel oils, were produced at lower ratios. Over-all yield of the principal oils was 83.7 percent compared to 82.5 percent in the earlier period.

Ethyl research takes a new approach to match future fuels and engines

By H. J. GIBSON, Technical Director, Ethyl Corporation Research Laboratories

COMBUSTION characteristics of future gasolines in tomorrow's engines have been defined in an extensive study recently completed in the Detroit Research Laboratories of Ethyl Corporation. This project pursued these two basic objectives.

First, to find out how variations in hydrocarbon composition, sensitivity and other characteristics would affect the ability of gasolines to meet the fuel requirements of tomorrow's engines.

Second, to determine how future engines could be modified to permit effective use of the widest possible range of fuel characteristics.

Engine Adjustments Lower Octane Requirement

Three high-compression test engines were selected for their high volumetric efficiencies and because each represented a different philosophy of combustion-chamber design. Compression ratios were increased to 11-to-1, a ratio that can be expected in passenger car engines in the near future.

Each engine was completely calibrated on an engine dynamometer in order to assure realistic tailoring of the carburetion and ignition characteristics of the engine for the most effective use of commercial-type gasolines.

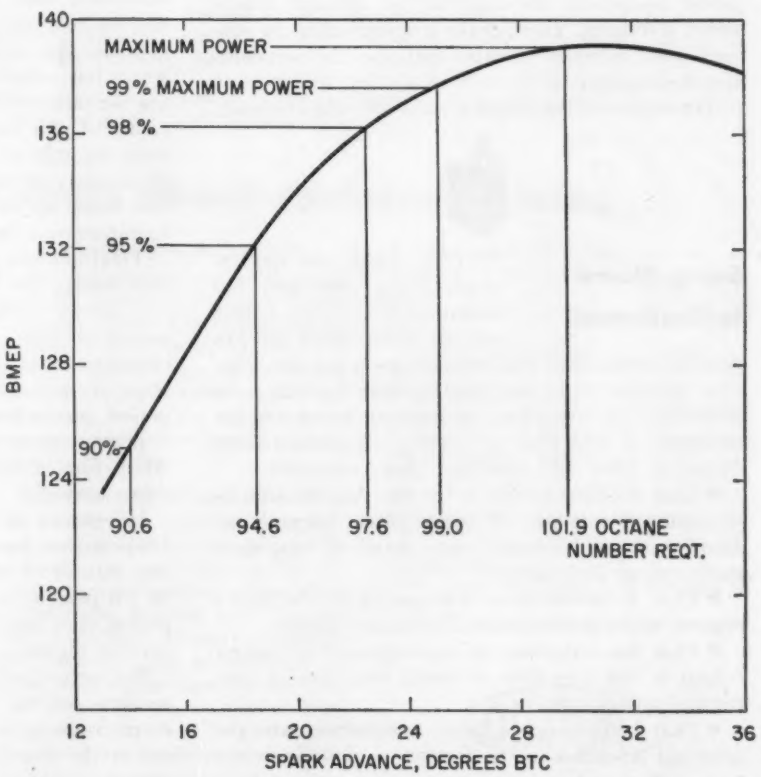
The engines were then installed in automobiles for road ratings of the fuels under test. Over one hundred commercial-type gasolines, including a wide variety of hydrocarbon compositions, were rated in these vehicles under carefully controlled conditions on a chassis dynamometer.

Results of the investigation indicate that a number of compromises can be made between engine performance and engine-fuel requirements.

For example, it was possible to lower the octane requirement with only nominal power loss and without significantly affecting fuel economy, by adopting slight modifications of spark advance and carburetor design.

It was further shown that it will be desirable for refiners to maximize the paraffinic and aromatic contents of their fuels in order to attain satisfactory operation at high engine speeds.

Low-cost olefinic blending components will continue to be effective in meeting the Research-octane-number specification required to satisfy the engine at low speeds.



This graph illustrates the relation between ignition timing and engine output for one engine at one speed. With ignition timing set for maximum power, the antiknock requirement is 101.9 octane number. When ignition timing is retarded to 99 per cent of maximum power, the octane requirement is reduced to 99. Thus, engine requirement can be reduced 2.9 octane numbers by sacrificing only one per cent in power.

For more data on advertised products, use Readers' Service Cards, last page.

Equation Predicts Road Octane Number

Using a digital computer, Ethyl statisticians analyzed the vast amount of data obtained from the tests. Extensive correlation equations were developed to aid refiners in blending their gasolines to the actual road antiknock requirements of current and future cars.

The best linear relation existing between road octane number and fuel-inspection data, such as Research and Motor octane numbers and hydrocarbon composition, was determined for each car.

Analysis of these equations showed Research and Motor octane numbers do a good job of defining road gasoline performance at low engine speeds.

At high speeds, however, consideration of gasoline composition, in addition to Research and Motor octane numbers, is useful in predicting gasoline antiknock performance. The correlation equations took the following form:

ROAD OCTANE NUMBER = A
+B *(Research Octane Number)*
+C *(Motor Octane Number)*
+D *(% Olefins)*

where A, B, C, and D are constants determined by analysis.

Additional properties, such as the volatility of the gasoline, do not materially enhance the degree of correlation.

Ethyl studies of the potential of future fuels and engines continue. The results will be distributed to oil companies. The data also will be discussed with automotive companies to acquaint them with the probable composition of future fuels as they may affect future engine design.

We believe such efforts will help to preserve a reasonable relationship between the advantages of high compression engines and their octane requirements.

In Ethyl's extensive road-rating program a digital computer was used to provide maximum statistical interpretation of the test data.

How Ethyl Research Is Helping You

Because of Ethyl's interest in the mutual problems of the petroleum refiner and automobile manufacturer, the extensive research program briefly described here was initiated to define the antiknock performance of future gasolines in tomorrow's engines.

This progress report is one more example of how Ethyl Research—outstanding in the study of engine-fuel relationships—continues to be of service to the petroleum industry.

Copies of the detailed report, "Matching Gasoline Antiknock Performance and Future Engines," presented at the May, 1957 meeting of the API Refining Division at Philadelphia, may be obtained from your Ethyl representative.

ETHYL CORPORATION
New York 17, N. Y.

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This Sunday Drive
REQUIRES A 7-DAY WEEK

Today's refineries are working on an around-the-clock basis and one of the reasons is the ever increasing demand for automotive gasoline. With the number of vehicles on the road still increasing, many experts foresee a 4 percent increase in the sale of gasoline and diesel fuel this year.

Polyrad—a filming amine inhibitor and detergent—can help refineries maintain peak production. As a detergent, Polyrad keeps metal surfaces clean to maintain throughput and increase heat transfer. As an inhibitor, Polyrad reduces corrosive damage to a minimum; cuts down time for maintenance.

If you are among the few who are not familiar with Polyrad, a Hercules representative will be glad to discuss how this product can meet your specific requirements. Polyrad is always quickly available from conveniently located stocks throughout the country and overseas.

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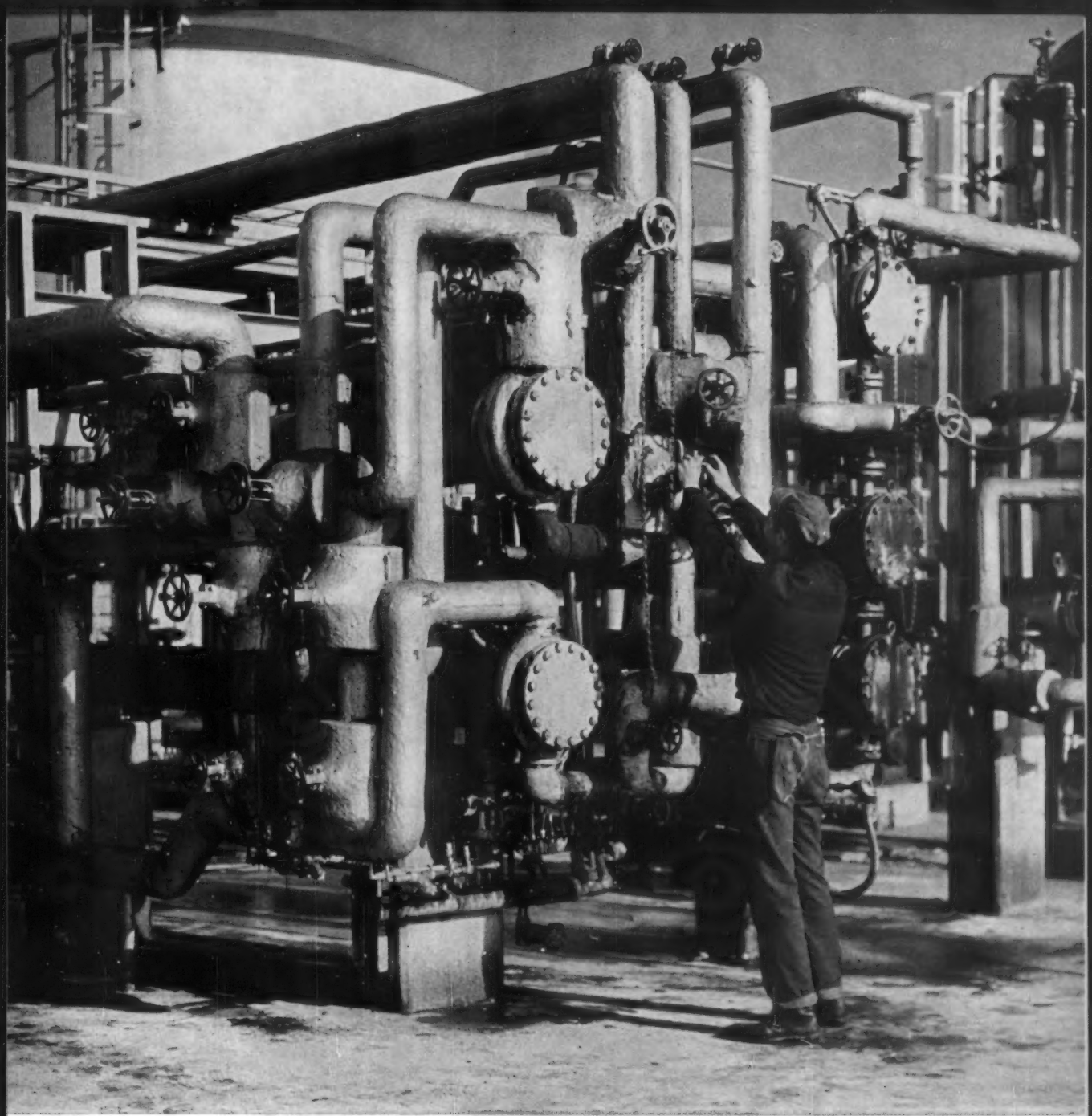


Easy way to keep tall oil moving: Aloyco jacketed valves

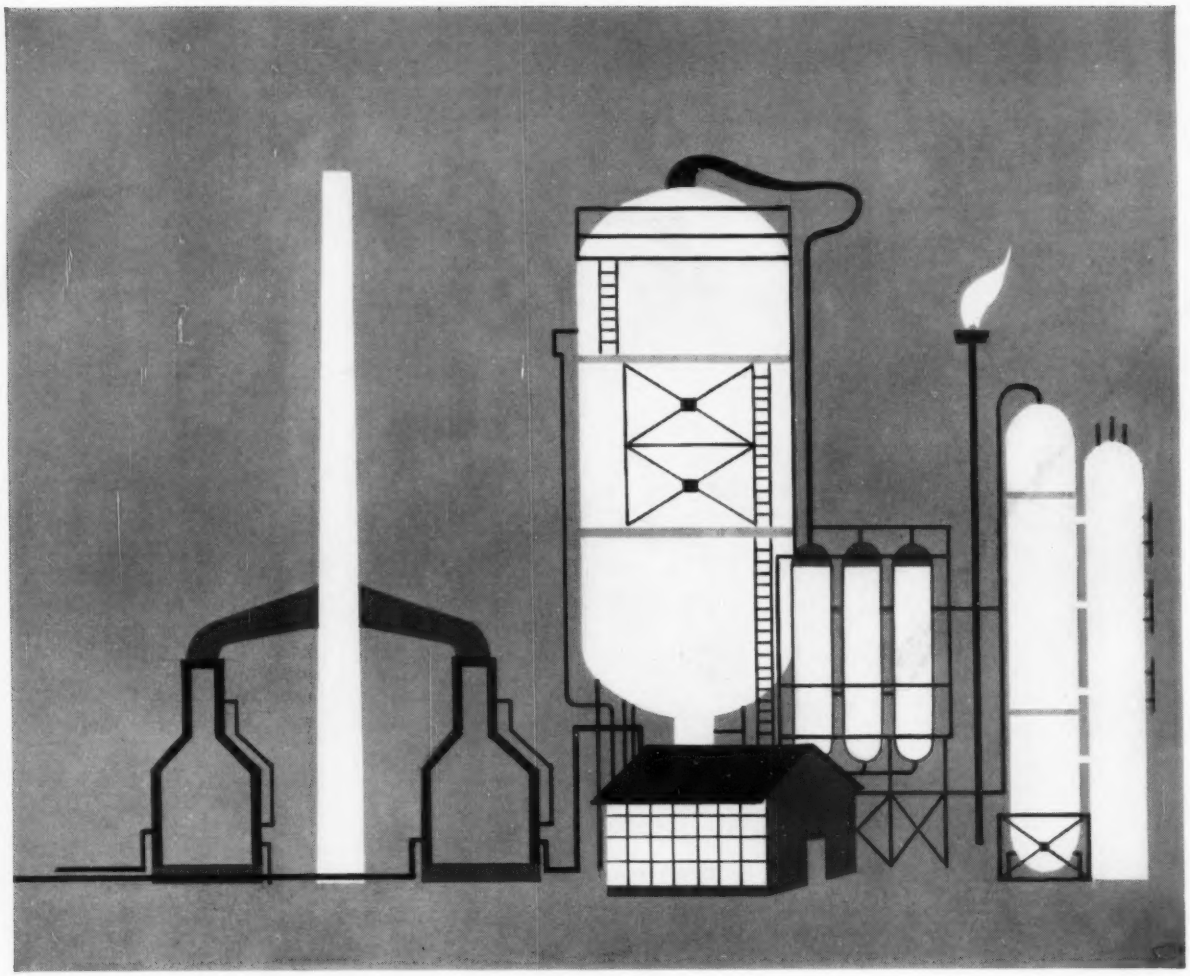
You're looking at a portion of the recently completed tall oil fractionation plant Foster Wheeler built for Union Bag-Camp Paper Corporation near Savannah, Ga.

The jacketed Aloyco stainless steel valves (with red hand wheels) get quite a workout in the two stage fractional distillation process here. Rosin and an intermediate fatty acid are produced in the first stage. Then the fatty acid is rerun through the main fractionating tower to produce a refined product for the manufacture of high grade alkyd resins, processing oils, soaps and chemical intermediaries.

Completely jacketed Aloyco valves are designed to ease handling of tars, tar oils, rosins and other materials difficult to move at room temperature.

Aloyco's integrally cast, completely jacketed valves insure long life and low maintenance in high temperature corrosive service. For more information, write Alloy Steel Products Co., 1301 West Elizabeth Ave., Linden, N. J. 71

ALLOY STEEL PRODUCTS CO., LINDEN, NEW JERSEY



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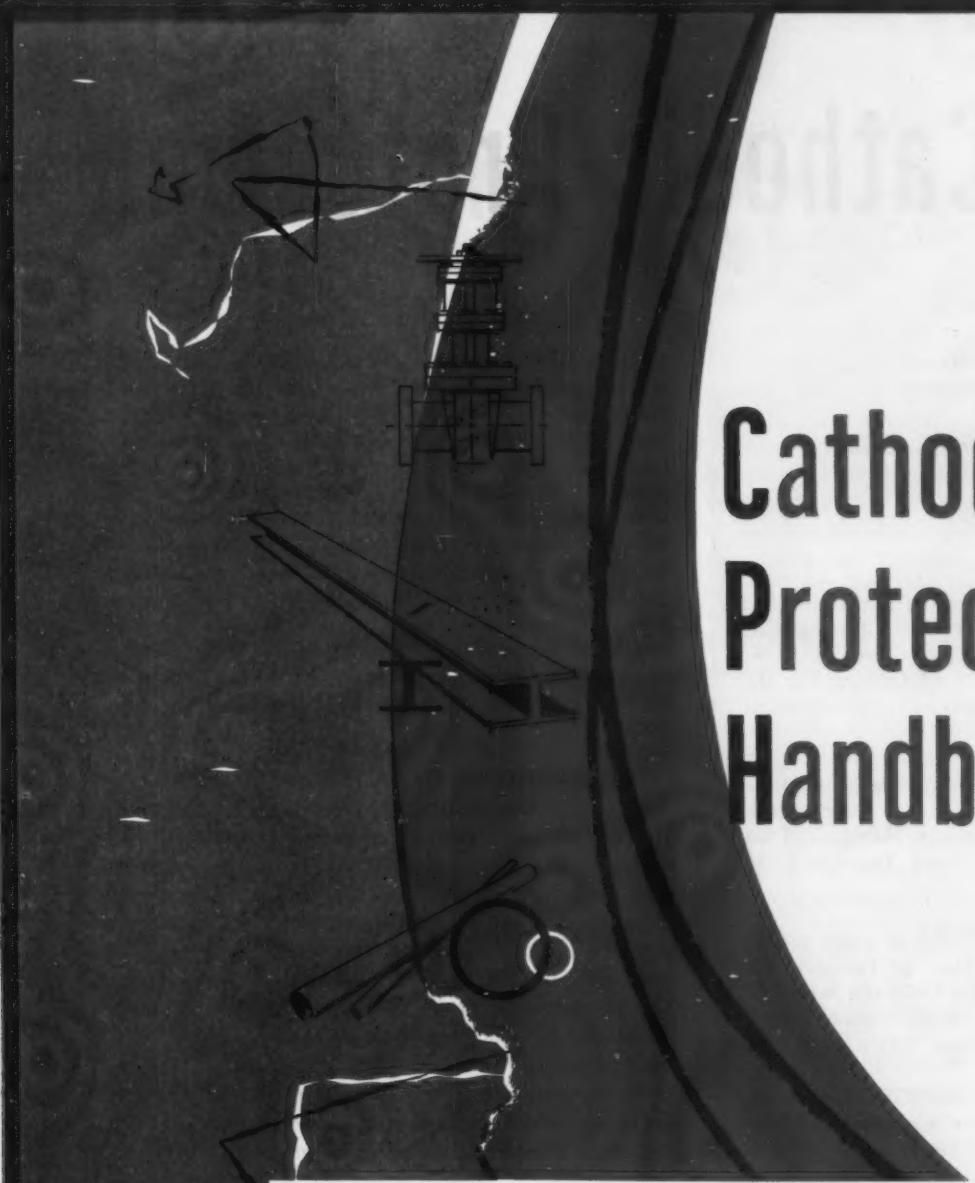
Petroleum Refiner

JUNE, 1957

Cathodic Protection Handbook



Here's What You'll Find Inside

FUNDAMENTALS of Cathodic Protection

FIELD MEASUREMENTS
- Fundamental Field Measurements
- Measuring Techniques
- Currents
- Potentials
- Interpretation of Measurements
- Anode Current
- Structural Potential

CONDENSERS AND HEAT EXCHANGERS
- Heat Exchangers
- Galvanic Protection
- Galvanic Corrosion Design Factors
- Galvanic Protection Design Factors
- Designing and Installation

PROTECTION OF MARINE EQUIPMENT
- Internal Protection of Sea Water
- Pipe Lines
- Design
- Installation Methods
- Ships, Boats and Barges
- Installation Considerations for Application of Cathodic Protection to Marine Craft
- Tanks
- Sheet Piling

UNDERGROUND PIPE LINES
- Installation Procedure

CATHODIC PROTECTION COSTS
- Total Costs
- Cost Per Unit Surface

Petroleum Refiner

Cathodic Protection

Oliver Osborn, C. F. Schrieber, W. B. Brooks, R. C. Jorgensen and Burke Douglas
The Dow Chemical Company, Freeport, Texas

About the Authors

OLIVER OSBORN is director of the Electrochemical Engineering department for The Dow Chemical Co., Freeport, Texas. He received his B.S. degree in chemical engineering from Texas A & M College. For the past 15 years he has done corrosion and electrochemical research.

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Osborn

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Schrieber

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Brooks

Jorgensen

Douglas

AS A RESULT of intense interest in the use of magnesium anodes for protection against corrosion in the Texas Division of The Dow Chemical Company, a handbook on this subject was prepared for use by company personnel. A condensed form of this handbook is now presented to readers of the PETROLEUM REFINER as a possible aid in better understanding cathodic protection and in applying it to plant corrosion problems.

It is to be pointed out that the practices and procedures outlined in the handbook were obtained from field experience. They have been found to be workable but do not necessarily represent the best way to do a job under all conditions. Every corrosion engineer always has his own pet short cuts to improve the efficiency of his work.

FUNDAMENTALS OF CATHODIC PROTECTION

In nature, energy tends to "run down hill". A metal possesses chemical energy and seeks a low level by releasing it through chemical action, i.e., corrosion. When iron corrodes, it "runs down hill" and heat is released, although so slowly as to be imperceptible. As a matter of fact, the corrosion products of many metals, especially iron, are quite similar to their ores as found in nature. The electromotive series (Table 1) provides a rough measure of the tendency of metals to corrode or revert to their native state.

The electrolytic nature of corrosion may be visualized by comparison to a flashlight battery (Figure 1). The zinc shell corrodes, forming zinc ions, which enter the

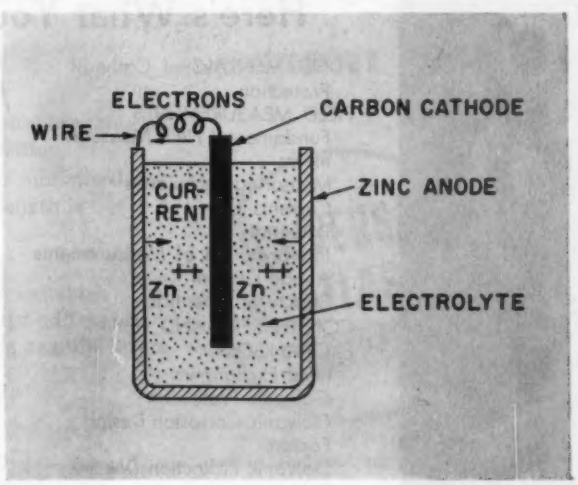

FIGURE 1—The Flashlight Battery. Zinc corrodes forming zinc ions which enter the electrolyte. Current flows from the corroding zinc anode to the carbon cathode as a result of the potential difference between the zinc and carbon and the presence of the electrolyte.

Handbook

How it Works
Where to Install
What it Costs

electrolyte. Current flows from the zinc anode to the carbon cathode as a result of the potential difference between the zinc and carbon in the presence of the electrolyte. The flow of this current obeys Ohm's Law, a relationship between current flow, voltage, and resistance. Ohm's Law states that I (current flow in amperes) equals V (volts) divided by R (resistance in ohms).

Many circumstances can cause potential differences to exist on the surface of a metal, which in turn allow a corrosion current to flow. Some of these conditions are:

1. Scratch in mill scale or permeable paint.
2. Oxygen-depleted area under a barnacle or deposit of mud.
3. Steel partly in poorly aerated soil and partly in aerated soil.
4. Region of locally high velocity, as in partly obstructed tube.

Numerous other examples could be cited but all occur in one of the following categories:

1. Two different metals in the same electrolyte.
2. Two metals in different electrolytes.
3. The same metal in two concentrations of the same electrolyte.
4. The same metal in different electrolytes.
5. The same metal in the same electrolyte at different temperatures.

To eliminate corrosion it is obvious that the electric current which is producing the corrosion must be stopped.

As defined above, Ohm's Law shows that this current is influenced by voltage and resistance. Therefore, if all voltage differences can be minimized by such practices as uniform environments, and avoidance of the use of dissimilar metals, corrosion can be controlled. If resistances can be kept very high through the use of paint coatings or electrical isolation of dissimilar metals, corrosion can be controlled. A third, simple, and very frequently used method for controlling corrosion is to "buck out" the corrosion current with an equal and opposite current applied from an external source. This practice is known as cathodic protection. When a current is made to pass into a metal submerged in a conducting media, a special opposition to the current flow develops at the surface of the metal. This opposition manifests itself as a back voltage and is termed polarization. As the rate of current passage is increased, a condition will be reached whereby the entire surface of the metal will assume the same back voltage. When this happens, cathodic protection has been achieved, for voltage differences no longer exist which can generate a corrosion current.

FIELD MEASUREMENTS

The cathodic protection circuit can be divided into two parts: the internal or electrolytic circuit and the external or electrical circuit. For example, in Figure 2, the soil

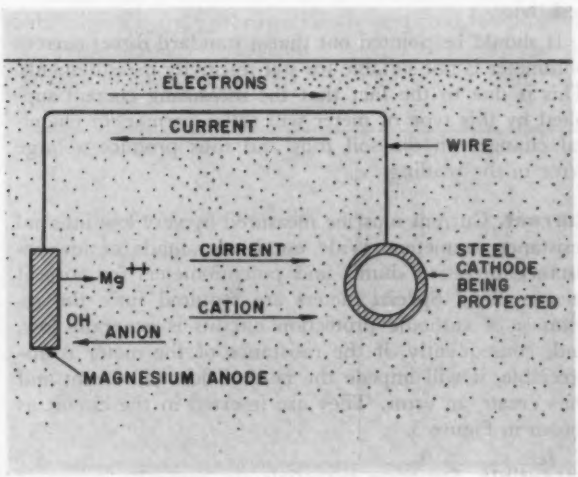

FIGURE 2—It is possible to measure the half cell voltages of the anode and cathode. Great practical value is derived from this means since by measuring the half cell voltage of the protected structure it is possible to determine if protection has actually been obtained.

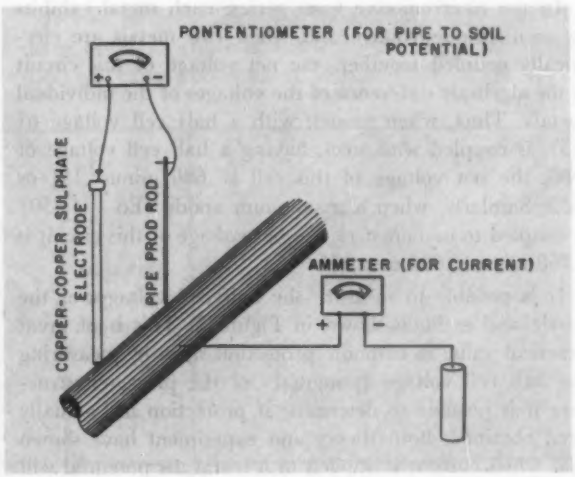

FIGURE 3—Structure potentials are generally measured with a copper-copper sulfate reference electrode. The potential of this electrode does not change when used intermittently; consequently, when it is compared with other metals, the relative potential can be obtained.

TABLE 1

Electromotive Series

	Potential Neg. to Saturated $CuSO_4$ Half Cell (Volts)
Magnesium (Galvomag alloy)	1.750
Magnesium (H-1 alloy)	1.550
Zinc	1.106
Aluminum (ALCLAD 3S)	1.016
Cast Iron (fresh)	.686
Carbon Steel	.686
Stainless Steel Type [2] 430, 17% Cr	.646
Ni-Resist Cast Iron, 20% Ni	.616
Stainless Steel Type [2] 304, 18% Cr, 8% Ni	.606
Stainless Steel Type [2] 410, 13% Cr	.596
Ni-Resist Cast Iron, 30% Ni	.566
Ni-Resist Cast Iron, 20% Ni + Cu	.536
Naval Rolled Brass	.476
Yellow Brass	.436
Copper	.436
Red Brass	.406
G. Bronze	.386
Admiralty Brass	.366
90:10 Cu-Ni + .8% Fe	.356
70:30 Cu-Ni + .06% Fe	.346
70:30 Cu-Ni + .47% Fe	.326
Stainless Steel Type [2] 430, 17% Cr	.296
Nickel	.276
Stainless Steel Type [2] 316, 18% Cr, 8% Ni, 3% Mo	.256
Inconel	.246
Stainless Steel Type [2] 410, 13% Cr	.226
Titanium (commercial)	.226
Silver	.206
Titanium (high purity)	.176
Stainless Steel Type [2] 304, 18% Cr, 8% Ni	.156
Hastelloy C	.156
Monel	.156
Stainless Steel Type [2] 316, 18% Cr, 8% Ni, 3% Mo	.126

[1] Based largely on data from 'Corrosion Testing', F. L. LaQue, Proceedings A.S.T.M., Volume 51, pages 1-89, 1951.
[2] Note that each stainless alloy occupies two positions, the upper one for the 'active state' and the lower one for the 'passive state'.

is the internal circuit and the pipeline and anode lead wire make up the external circuit.

In the electromotive force series, each metal exhibits its own unique voltage and when two metals are electrically coupled together, the net voltage of this circuit is the algebraic difference of the voltages of the individual metals. Thus, when monel, with a half cell voltage of .151, is coupled with steel, having a half cell voltage of .686, the net voltage of this cell is .686 minus .151 or .535. Similarly, when a magnesium anode (Eo = 1.750) is coupled to carbon steel, the net voltage of this circuit is 1.750 minus 0.686 or 1.064.

It is possible to measure the half cell voltages of the anode and cathode shown in Figure 2. This is of great practical value in cathodic protection since by measuring the half cell voltage (potential) of the protected structure it is possible to determine if protection has actually been obtained. Both theory and experiment have shown that when current is applied to a metal, its potential will increase (become more negative) and the voltage at which corrosion stops is both finite and reproducible.

The total resistance of a circuit is the sum of the resistance in the connection wires and the media in which the circuit is immersed. In general, the media resistance will be many times greater than the circuit resistance. Media resistance will vary through wide limits from a fraction of an ohm in salt brine to several thousand ohms in certain types of soils.

Fundamental Field Measurements. The first measurement generally made is to determine media resistivity. This is done in order to ascertain the expected output of an anode. Resistivity is defined as the resistance of a unit volume of the media. The volume generally chosen is the centimeter cube and hence the value is termed ohm-cm. Note that this value is not the same as the term "R" (circuit resistance) previously mentioned.

After the cathodic protection system has been designed and installed, two field measurements are made:

1. Anode current flow is read to determine if the design current flow has been realized.
2. The potential (voltage) of the protected structure is measured to determine if protection has actually been secured.

Measuring Techniques—Media Resistivity. Two methods are used in standard practice for measuring resistivity. The first method involves the use of a megger, in which a pulsating DC current is passed through the ground between two widely spaced electrodes. The potential drop across a known distance is measured and the reading on the megger then translated into resistivity. This method of measurement, although somewhat cumbersome, has the advantage of measuring the average resistivity between the current electrodes and down to a depth approximately equal to the distance between the electrodes.

The second method involves the use of a single rod which is inserted into the ground to the depth at which it is desired to make the measurement. The tip of the rod is insulated from the body, and an AC bridge is then used to measure the resistance between the two segments of the rod. By the use of a suitable "rod calibration factor," the reading obtained can be converted into specific resistivity.

It should be pointed out that a standard direct current ohmmeter is not suitable for soil resistivity measurements. This is due to the fact that the measuring current supplied by this type of meter will cause permanent chemical changes on the soil rods and thus produce a large error in the reading.

Current. Current must be measured by very low internal resistance ammeters. Wide use is also made of low resistance precision shunts and potentiometers for current measurement. Special meters are required since the resistance of cathodic protection circuits is generally low, and, consequently, if the resistance of the meter is appreciable, it will impede the normal flow of current and thus create an error. They are inserted in the circuit as shown in Figure 3.

Potentials. Structure potentials are generally measured with a copper-copper sulfate reference electrode as shown in Figure 3. The potential of the Cu-$CuSO_4$ electrode does not change when used intermittently, and, conse-

quently, when it is compared with other metals through the aid of a potentiometer, the relative potential of the metal in question can be obtained. The tip of the electrode is placed as close as possible to the structure being measured. The function of the pipe prod rod shown in Figure 3 is to contact the structure electrically. If other means of connection are more convenient they are acceptable. The instrument employed to make the measurement is a potentiometer which draws no current or a high resistance voltmeter which draws only a very small current.

Interpretation of Measurement—Resistivity. As mentioned previously, resistivity is used in determining the expected output of the anodes. Resistivity of soils may also be used as rough approximation of corrosivity. In general, the lower the resistivity of the soil, the more corrosive it is, although there are a number of exceptions to this rule.

The following is a rough classification of soils according to resistivity:

Low Resistivity	– 100-500 ohm-cm
Moderate Resistivity	– 500-3000 ohm-cm
High Resistivity	– 3000-10,000 ohm-cm

Anode Current. Anode current is used in predicting anode life and in calculating the current density which is being delivered to the protected structure. One pound of magnesium has the capacity to produce about 500 amp-hrs.

Structure Potentials. As stated previously, structure potentials are valuable criteria as to the condition of the structure. Figure 4 has been prepared as a guide in interpreting pipe line potential measurements. In this case, the common terminology for the structure potential is "pipe-to-soil potential." (Note that on this figure a potential of —0.80 volt is considered protection while a value of —0.85 volt was generally stated to represent this condition. Although the—0.85 value theoretically represents complete protection, we believe that for practical purposes a value of —0.80 volt will give adequate protection.) Although Figure 4 was specifically prepared for pipelines (soil installation) conditions (3) and (4) may also be applied to marine structures.

HANDBOOK | CATHODIC PROTECTION

GALVANIC PROTECTION OF CONDENSER AND HEAT EXCHANGER HEADS

Galvanic Protection from Galvanic Corrosion. Ten years experience with the cathodic protection of condensers and heat exchanger heads has eliminated trial and error methods in plant-wide applications such that all installations are now according to plant engineering standards. It is suggested that the electromotive series (Table 2) be considered when selecting materials for use in any equipment which is to be submerged in a liquid or buried in the soil, to determine the compatibility of certain metals when connected to form a galvanic couple.

TABLE 2
Galvanic Series of Metals and Alloys in 13 Foot Per Second Sea Water at 25° C.

MATERIAL	Potential Reference $Cu\text{-}CuSO_4$, Half Cell
Magnesium (Galvomag)	1.750
Magnesium (H-I Alloy)	1.550
Zinc	1.106
Cast Iron‡	.686
Carbon Steel‡	.686
Yellow Brass	.436
Muntz Metal†	.436
Aluminum Bronze†	.406
Aluminum Brass*	.396
Composition 'G' (88% Copper, 10% Tin, 2% Zinc)	.386
Admiralty*	.366
90:10 Cu-Ni + .82 Fe†	.356
70:30 Cu-Ni + .47 Fe*	.326
Monel	.151

* Suggested tube material.
† Suggested tube sheet material.
‡ Suggested water box material.

It can be seen from this table that condenser tubes made of 70:30 cupro-nickel when used on a monel tube sheet will cause a potential of .175 mv. (.326—.151 = 175)

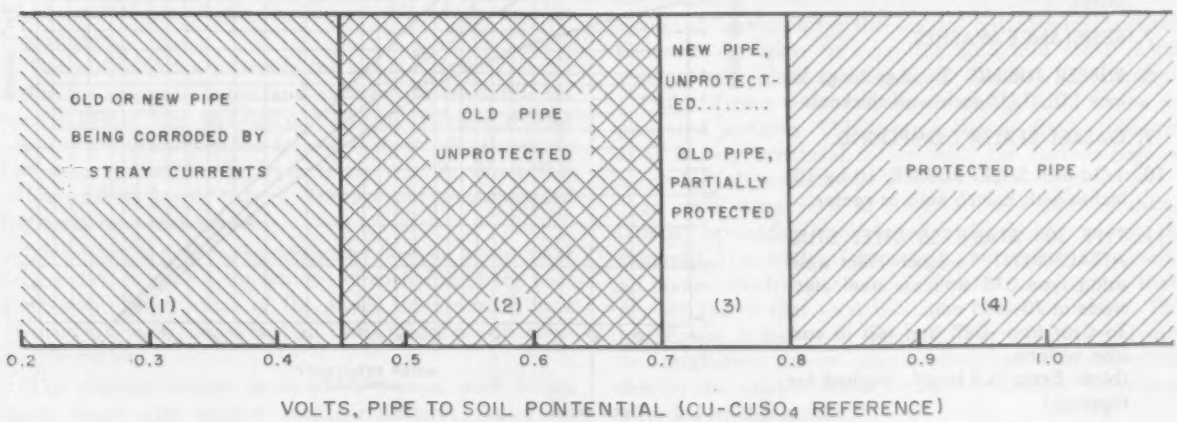

FIGURE 4—Use this graph as a guide to pipe-to-soil potential.

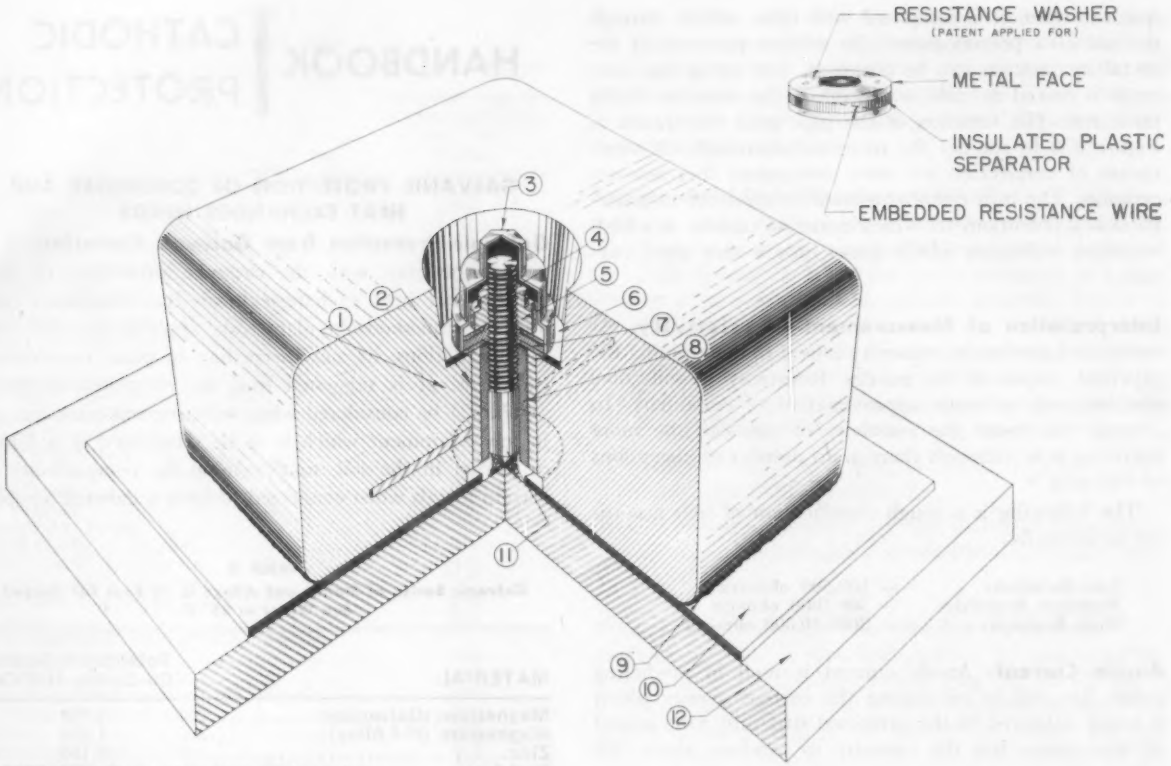

FIGURE 5a—(Above) Magnesium anode condenser head installation (using current restrictor).

1 & 2. 15-POUND MAGNESIUM ANODE, approximately 8 by 8 by 4 inches, having two 1 29/32 by ¾-inch pipe core cast in center with a ⅛-inch diameter cross bar welded to core and embedded in anode.

3. PLASTIC STUD PROTECTOR, ½-inch, 13 threads per inch.

4. ½-INCH STAINLESS STEEL STUD, extending 3⅝ inches above surface.

5. ½-INCH, 13 THREAD FLEX-LOCK NUT.

6. RUBBER GASKET for plastic stud protector.

7. RESISTANCE WASHER.

8. RUBBER TUBING, 2-inches long, ½-inch I.D., 1/16-inch wall thickness.

9. GASKET SEALER COMPOUND.

10. 1/16-inch SHEET RUBBER, 10 by 10-inches with ½-inch hole at center.

11. TYPE 304 STAINLESS STEEL STUD ATTACHMENT, To Steel—Fillet weld using type 310 stainless steel electrode at 70—105 amp.
To Cast Iron—Drill and tap in cast iron surface.
(Note: Extra stud length required for tapping.)

12. PROTECTED SURFACE.

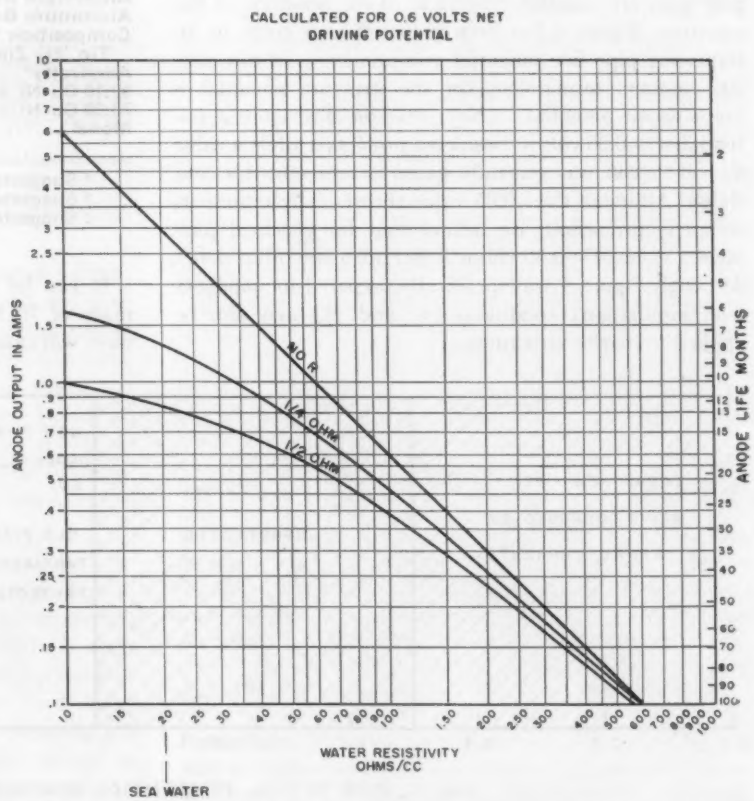

FIGURE 5—Use this chart for design installations using waters of various resistivities.

to exist between them which will cause a current to flow in such a direction that the tube ends will be galvanically attacked. Instead of the above selection of metals, if 70:30 cupro-nickel tubes are selected (having a potential of .326), Muntz metal tube sheet (having a potential of .436), and a condenser head of mild steel (having a potential of .686) it can be seen that the Muntz metal tube sheet will tend to protect the 70:30 tube ends and the mild steel condenser head will tend to protect both the Muntz metal tube sheet and the 70:30 cupro-nickel tube ends and all corrosion will take place on the mild steel. Now, should a magnesium anode be introduced into this system, a current would flow from the magnesium anode to all other components, thereby preventing corrosion on all elements except the magnesium anode. The use of magnesium therefore allows more extensive use of steel as tube sheets and header material.

Galvanic Corrosion Design Factors. If, in the original design of condensers and heat exchangers, some consideration is given to the magnitude of the galvanic action produced by various dissimilar metals, a great many of the serious corrosion problems would cease to exist. Some of the more predominant design factors are:

1. **Area Balance.** Never have a small area of less noble metal exposed to a large area of a more noble metal. This greatly increases the galvanic activity and rapidly corrodes away the less noble metal. The reverse of this, where a small area of noble metal is coupled to a large area of less noble metal would not present a serious corrosion condition because of the large difference in area. The corrosion of the less noble metal would be negligible.

2. **Compatibility of Metals.** If a reasonable choice of two metals exists, try to choose metals that are close to each other in the galvanic series. If the more noble metal has the smaller area, satisfactory results can be expected.

3. **Space for Galvanic Protection.** It is suggested that sufficient space be made available when new heat exchangers are designed to accommodate a standard 8" x 8" x 4" anode.

Galvanic Protection Design Factors. Since the 8" x 8" x 4" 15-pound anode is standard for condenser and heat exchanger service, all design factors are based upon its characteristics. Figure 5a shows this anode and its components.

The addition of a resistor in the anode electrical circuit limits the current output and thereby increases the expected life of the installation. Usually ¼-ohm resistor washers are recommended for use with standard anodes; however, ½ and 1-ohm washers are used at times. Resistor washers larger than 1 ohm are not recommended for use in heat exchangers.

To protect a heat exchanger water box, an anode must be installed in each compartment of each end of the heat exchanger. The surface of the anode must remain bare (free of all paint or grease) in order to supply the protective current.

The current density required to protect steel in sea water varies with salinity (water resistivity), water velocity, and temperature.

Designing an Installation. Figure 5b can be used in the design of installations using waters of various resistivity. The three curves show the current output and expected life of a single 15-pound anode with no resistor, with a ¼-ohm resistor, and with a ½-ohm resistor. Figure 6 has been prepared for use in designing galvanic protective systems for seawater heat exchanger equipment using standard, 15-pound anodes (H-1 magnesium alloy). In using this chart, the following steps are recommended:

1. Compute the surface area of the compartment to be protected (in square feet). *Keep in mind that protection cannot be afforded the inner surface area of the tubes.*
2. Determine if space limitations will permit the use of a side-by-side installation or whether a single anode must be used.
3. Read from the chart the surface area which can be protected with ¼ ohm added resistance. Divide this area into the total area of the installation to obtain the number of groups which must be employed.
4. Read the expected life from the chart.

Under very special conditions of extremely high turbulence or very limited space it may be found necessary to eliminate the resistor in order to obtain the desired protection.

Should the above method of installation produce a design that requires anode renewal more often than the condenser is normally opened, it is very strongly recommended that the heat exchangers be opened and anodes replaced as required on a planned schedule. If the anodes are replaced when required and galvanic protection is continuously supplied, the planned shutdowns for the purpose of anode renewal will take the place of costly emergency shutdowns due to heat exchanger failure which would be expected without galvanic protection.

A monel or stainless steel securing stud is recommended for attaching anodes to a condenser cover plate. The reason for this selection is to avoid damage to the securing stud due to corrosion should the condenser be continued in service after the anodes have been dissipated. Galvanic corrosion between the stud and other metals will not take place so long as the anode is in operation.

Quite often a white calcareous coating will form on the protected surfaces. This coating should not be removed as it is very beneficial in reducing the current requirements for full protection.

In some cases, such as large turbine condenser installations, operators have found it desirable to cut the standard 51-pound magnesium anode in half, producing an anode which can be secured to the surafce in a manner similar to that used with the 15-pound anode. This installation is shown in Figure 7. The advantage of such an installation, where space is available, is increased life due to the small surface area per pound of magnesium afforded by this anode.

Anodes which are installed in pairs will have a reduced

output per anode due to the current interference produced by both anodes attempting to use the same current path through the water. This feature is desirable for longer life when less current is required from an anode installation.

CATHODIC PROTECTION OF MISCELLANEOUS MARINE EQUIPMENT

Internal Protection of Sea Water Pipe Lines. Service life of large sea water lines has indicated that extensive failures will occur in eight to ten years' time. Great expenses have been involved in the repair, or replacement, of these lines.

Cathodic protection with magnesium anodes can be successfully employed to protect the internal surfaces. Line size is a limitation to this practice, since on lines smaller than 24 inches the volume of the magnesium which is required to maintain protection for any appreciable length of time will materially reduce the capacity of the line.

Old lines as well as new lines may be protected. When an old line is protected, all rust scale and marine deposits will be spalled loose from the pipe; consequently, the physical layout of the system must be such that this scale will not interfere with the end use of the sea water, otherwise the scale should be mechanically removed from the line prior to the application of cathodic protection.

Experience has shown that lines internally coated with hot applied coal tars may also be cathodically protected. Experiments indicate that if the proper amount of current is used, the life of the coating will actually be increased.

Design. The current requirements for protection will vary with respect to water velocity, and whether the line is coated or bare. Table 3 gives a rough approximation of current demands for various conditions:

TABLE 3

Velocity Ft./Sec.	Bare Pipe ma./Sq. Ft.	Coated Pipe ma./Sq. Ft.
1–3	5–15	0.2
3–7	15–30	0.5

(The current demands shown in Table 3 and also in Tables 4, 6, and 7 will be reduced for subsequent installations due to the formation of a calcareous coating on the surface of the steel.)

Installation Mechanics. The method of installation generally employed is to lay a continuous string of anodes on the bottom of the line. Anodes having a ¾-inch longitudinal pipe core are strung on flexible steel cable

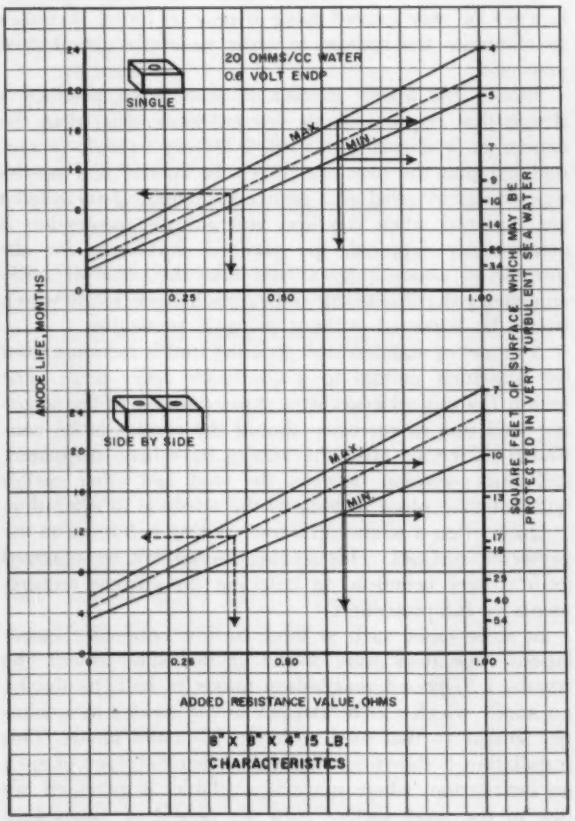

FIGURE 6—Use this chart in designing galvanic protection systems for sea water heat exchangers. It's based on standard 15-pound anodes.

FIGURE 7—In some cases, standard 51-pound magnesium anodes are cut in half, producing an anode which can be secured to the surface in

and then strings up to 100 feet long are snaked into the line through manholes placed at 200 foot intervals. Attachment of the anodes to the cable is made by driving wedges into the pipe core ends. Installation details are shown in Figure 8.

After the installation has been operating for approximately one month, appropriate resistances are inserted in the leads which extend to the outside of the pipe in order that proper installation life is obtained.

Typical Example: It is desired to design a cathodic protection installation for the bare internal surfaces of a 36-inch sea water line 2000 feet long. Rate of flow is approximately 3 feet per second. Steps:

- Assume installation is to last four years
- Surface area to be protected = (2000) (3.1416) (3) = 18,800 sq. ft.
- Reference to Table 3 indicates an approximate current demand of 15 ma/sq. ft. Then:

  Total current required = $\frac{(15)\ (18{,}800)}{1000}$ = amps = 282
- The largest practical anode for this size line is a 5-inch D-shaped 68-pound longitudinal cored anode.
- Since the 68-pound anode can deliver .800 amps, the number of anodes to employ is calculated as follows:

  Number of Anodes = $\frac{\text{Total Current Requirements}}{\text{Output per anode}}$ = 353
- This is equivalent to one anode every 5.7 ft $\left(\frac{2000}{353}\right)$ This is a practical distance, consequently the design is now completed. Installation will proceed according to Figure 8.

Use has also been made of a weld anode for internal pipelines. This anode is completely enveloped in a tough serviceable plastic. Current can be controlled by removing specified amounts of plastic from the anode surface. Since the weld anode is furnished in 24 and 44 pound units, the expected life is accordingly shorter.

Ships, Boats and Barges. Cathodic protection has been successfully applied in the corrosion control of ships, boats, and barges. However there are some special problems encountered in this application. These are:

1. Varying circuit resistance if the vessel moves from sea water to brackish water.
2. Susceptibility of some paint coatings to damage by cathodic protection.

a manner similar to that used with the 15-pound anode. The advantage of such an installation is increased anode life.

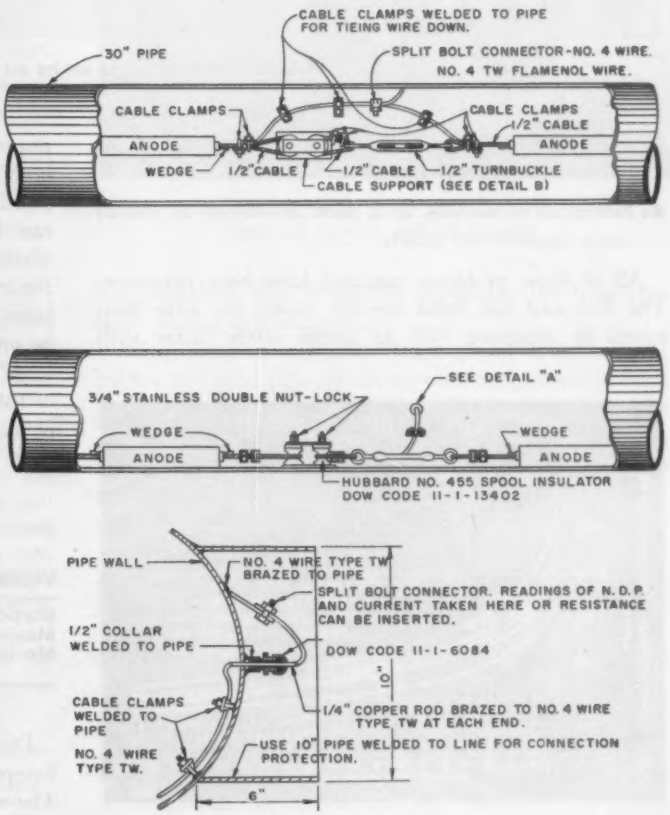
CABLE CLAMPS WELDED TO PIPE FOR TIEING WIRE DOWN.
30" PIPE
SPLIT BOLT CONNECTOR-NO. 4 WIRE. NO. 4 TW FLAMENOL WIRE.
CABLE CLAMPS
CABLE CLAMPS 1/2" CABLE
ANODE
ANODE
WEDGE
1/2" CABLE
1/2" CABLE
1/2" TURNBUCKLE
CABLE SUPPORT (SEE DETAIL B)
SEE DETAIL "A"
3/4" STAINLESS DOUBLE NUT-LOCK
WEDGE
WEDGE
ANODE
ANODE
HUBBARD NO. 455 SPOOL INSULATOR DOW CODE 11-1-13402
PIPE WALL
NO. 4 WIRE TYPE TW BRAZED TO PIPE
SPLIT BOLT CONNECTOR. READINGS OF N. D. P. AND CURRENT TAKEN HERE OR RESISTANCE CAN BE INSERTED.
1/2" COLLAR WELDED TO PIPE
DOW CODE 11-1-6084
CABLE CLAMPS WELDED TO PIPE
1/4" COPPER ROD BRAZED TO NO. 4 WIRE TYPE TW AT EACH END.
NO. 4 WIRE TYPE TW.
USE 10" PIPE WELDED TO LINE FOR CONNECTION PROTECTION.
6"

FIGURE 8—Protection of sea water pipe lines is accomplished by laying a continuous string of anodes, attached to a cable, in the bottom of the line.

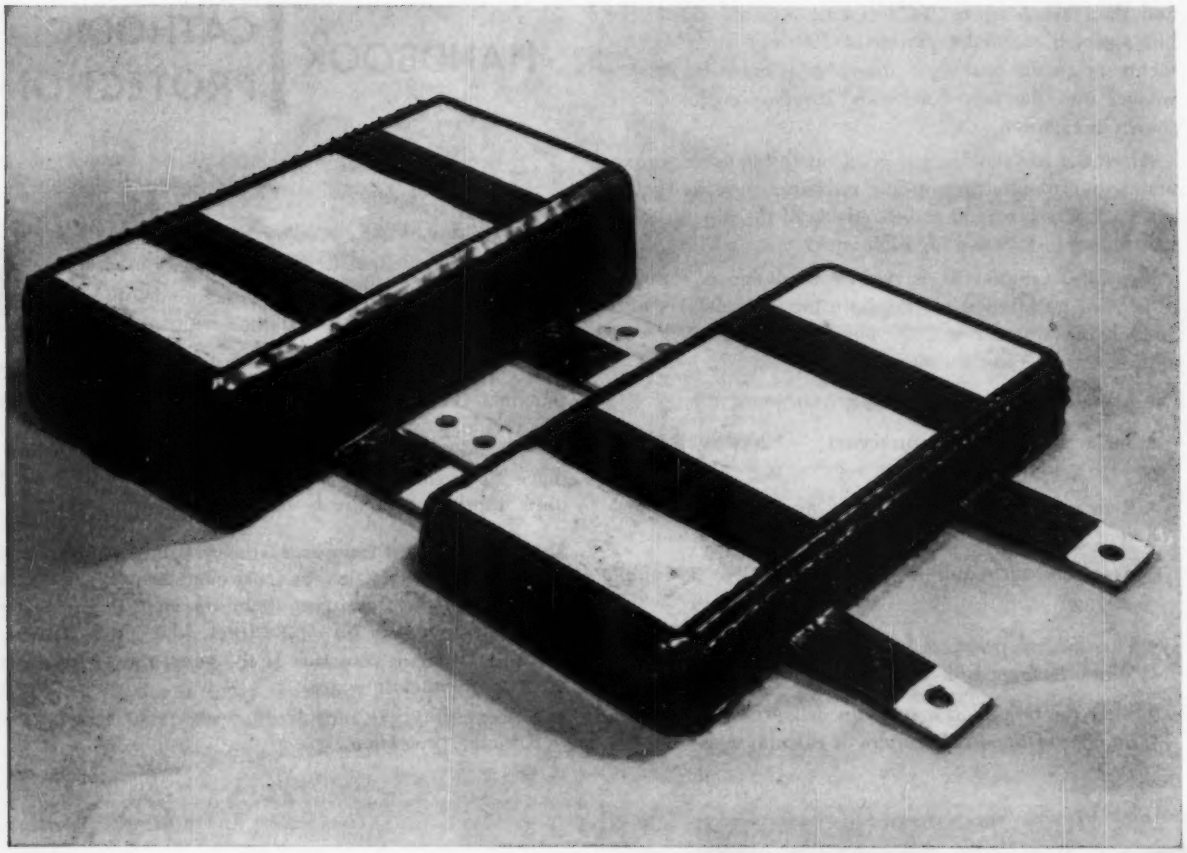

FIGURE 9—Plastic covered anodes are welded to ship hulls.

3. Possibility of physical damage to and removal of the anodes by striking objects in the water.

4. Electrical connection of a protected vessel to one or more unprotected vessels.

All of these problems can and have been overcome. The first and last items are not major but have been solved by designing with an ample safety factor with respect to time and/or current. The second problem has been overcome with the use of an anode that is completely enveloped in a tough, serviceable plastic. Current can be controlled by removing specified amounts of plastic from the anode surface. This anode is shown in Figure 9. The possibility of damage to the anode installation by striking objects in the water can be minimized by proper placement and/or by the use of protective steel 'cups' welded to the vessel in front of the anodes.

Table 4 shows current requirements for various types of marine applications.

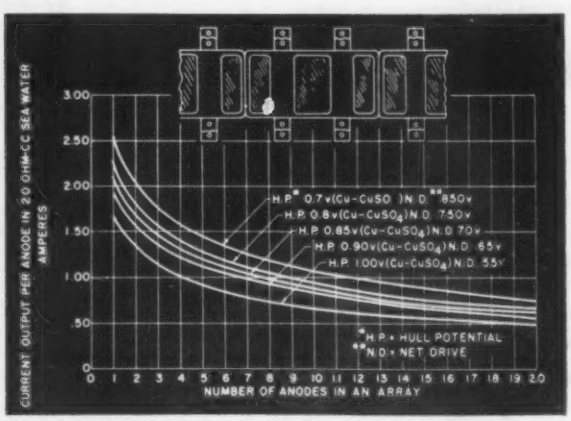

FIGURE 10—The life of plastic coated anode strings is directly proportional to the string length.

TABLE 4

VESSEL	Current Demand ma./Sq. Ft.
Stationary (bare)	2–3
Moving (bare)	5–10
Moving (painted)	4–8

Due to the high current demand and limited space, five-year life designs are not practical on marine craft. The engineer should design for one or, at the most, two-year life. Table 5 gives the current output and life for the recommended marine anode shapes.

TABLE 5
Current Output and Life for Marine Anode Shapes

Anode Type: (Based on H-1 Alloy)	Current (Amps) at 0.6 Volt Net Driving Potential	Life
60-lb., 18″x8″x8″ (individual).	4.5—5.2	8—12 mos.
As above, groups of 10 or more	2.2—2.8	16—20 mos.
44-lb., 18″x9″x4″ (individual) 0.66 ft² exposed	1.8—2.0	14—15 mos.
44-lb. anode, groups of 7 or more	0.9—1.2	>24 mos.
24-lb., 18″x9″x2″, same current as given for 44-lb. unit, ½ the life	.....	12 mos.
15-lb., 8″x8″x4″, with ¼ ohm resistor individual	1.3	8 mos.
As above, with ¼ ohm resistor, groups of 10 or more	0.6	18 mos.

INSTALLATION CONSIDERATIONS FOR APPLICATION OF CATHODIC PROTECTION TO MARINE CRAFT

After examining laboratory and field experiences, some valid considerations as to installation and design technique may be advanced as follows.

1. Determine the corrosion status and extent of marine fouling normally encountered prior to the initial installation.
2. Depending on vessel service conditions, design for an initial current density corresponding to those given in Table 4.
3. Distribute the anode strings as uniformly as possible over the hull surface. Care must be exercised to locate the anodes so that they are not vulnerable to damage.
4. Design for a one or two-year life. The life of magnesium anode strings is a function of string length. Figure 10.
5. A cathode potential of —0.800 volt Cu—$CuSO_4$ should be considered a minimum value for effective protection.
6. On hulls subject to fouling, a decision as to the reduction or elimination of anti-fouling coatings should be made upon examining the hull after a one-year interval.

Tanks. Cathodic protection by the use of magnesium anodes has proven to be an economical method of corrosion control on many large process tanks. Major types of tanks under protection at this time include sea water make-up tanks, Dorr tanks and brine tanks.

The tank corrosion problem involves several major considerations. These include the rise and fall of the liquid level, the corrosivity of the liquid contained, and the ultimate use of the liquid. If the liquid is sea water and is rather stagnant, very little or no protection may be needed. If it is moving sea water, protection is necessary. If the liquid is brine, cathodic protection is necessary whether the liquid is moving or not.

Table 6 shows design information gathered from extensive field experiments.

TABLE 6

Environment in Tank	Current Demand
Moving Sea Water	5–10 ma./Sq. Ft.
Brine Tanks	8–10 ma./Sq. Ft.

Figure 11 shows a typical installation. The anodes most commonly used are 50-pound castings with a ¾-inch pipe core through the center. These are suspended from an arm on a cable and are held in place by special wedges which hold the pipe core fast to the cable. An external resistor is used to regulate the current.

Sheet Piling. Sea water flumes and other steel sheet piling can be protected by the use of magnesium anodes. In considering this application, it is necessary to study

FIGURE 11—For storage tanks filled with sea water, anodes are suspended from an arm on a cable.

the conditions that prevail. In particular, the water velocity should be considered.

When very low velocities (such as are found around harbor and tidal pilings) are encountered, corrosion rates and therefore the degree of cathodic protection required are governed largely by the pressure of water contaminants. Appreciable water velocities of course bring about higher, more aggravated corrosion rates.

In most cases the current output of the anodes normally used in sea water will be greater than needed. The current can be regulated with nichrome resistance elements.

Miscellaneous. Many types of sea water handling equipment may be economically cathodically protected. Sea water screening equipment, large gate valves, pump sections, etc., fall into this category. The principal limitations to these installations are space considerations to accommodate the magnesium and the ability to attach the magnesium under highly turbulent conditions. The availability of a wide variety of anode shapes and the

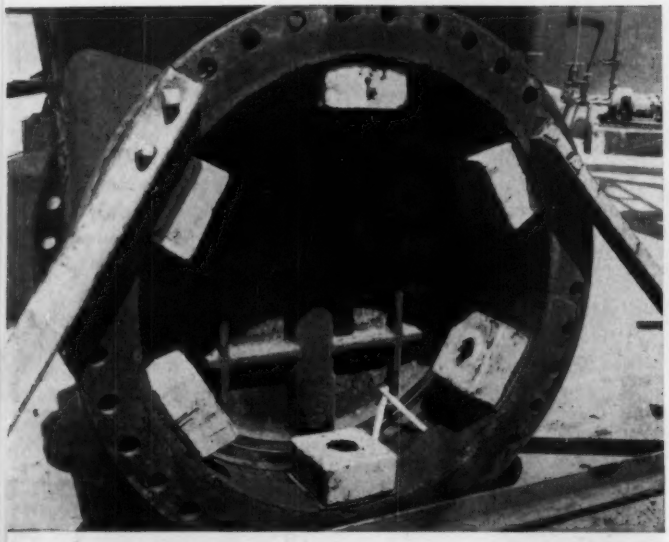

FIGURE 12—15-pound anodes protect this 48-inch gate valve.

liberal use of ingenuity in making attachments tend to minimize these problems.

The current requirements for protection will vary with respect to water velocity and whether the structure is coated or bare. Table 7 gives a rough approximation of current demands for various conditions.

The wide variation of current demand in relation to velocity is to be particularly emphasized. Local conditions, such as degree of turbulence and the presence or absence of crevices, pockets or corners which require protection will determine whether high values or low values are chosen. A trial installation is the best means of arriving at the true protective current needed. Figures 12 and 13 show typical installations.

TABLE 7

Velocity, Ft./Sec.	Bare ma./Sq. Ft.	Coated* ma./Sq. Ft.
1–3	5–15	0.2
3–5	15–25	0.5
5–10	25–100	0.5
10+	100+	0.5

* Coating referred to is hot applied coal tar. The current demand figures given are tentative only, since this will vary with time and coating stability.

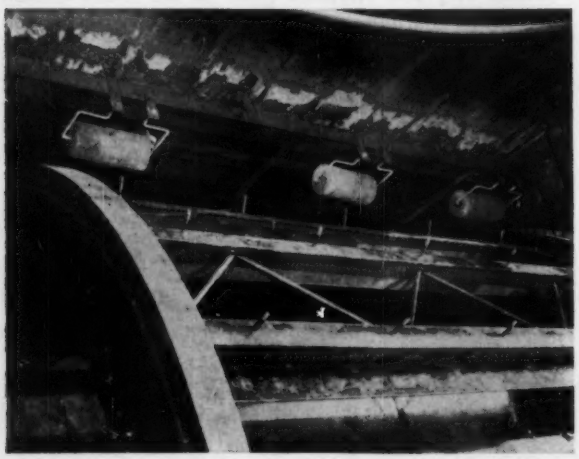

FIGURE 13—51-pound anodes protect sheet piping at this sea water intake station.

CATHODIC PROTECTION OF UNDERGROUND PIPE LINES

General. Cathodic protection of buried pipe lines is made possible by an electric current flowing from an external source to the structure to be protected. Although the current requirements for complete protection are frequently the point of argument, the criterion accepted by field engineers is a solution potential of 0.80-0.85 volt ($Cu\text{-}CuSO_4$ ref. electrode) on the cathode. When the potential of the line is raised to this value, corrosion on the structure is completely arrested or reduced to a negligible rate.

In order to achieve this protection, magnesium anodes are planted in the ground adjacent to the structure to be protected and electrically bonded to the pipe. Positive current in this circuit will flow from the anode through the earth onto the pipe, gradually consuming the magnesium anode and preventing corrosion on the steel structure.

In the cathodic protection system to be described, magnesium anodes are placed along the pipe in groups, called anode stations, sometimes draining as much as 3 to 4 amperes from a single station. Solution potential test points are placed between anode groups (preferably midway) for pipe polarization checking.

Magnesium anodes are partially self-regulating in their current output by supplying additional current if and when the pipe coating deteriorates or is mechanically damaged.

In order to simplify the design of magnesium anode installations, it is often convenient to set up certain standardized procedures which may be readily followed in the field. A typical example of how such a standardized procedure might be used is as follows:

1. All buried pipe lines are coated and wrapped.
2. Installation will be designed according to the following procedure.
   a. Make soil resistivity measurements along the pipe line or pipe line right-of-way at approximately 3000 to 5000-foot intervals, giving special emphasis to potential anode station locations such as road crossings, river and canal crossings, and other places which are accessible by car. Also check swamps, sloughs, and other perpetually moist areas.
   b. Divide line into sections according to the following soil resistivity ranges and compute the length in feet of each section:
      Section No. 1—soil resistivity from 50 to 500 ohms/cc
      Section No. 2—soil resistivity from 500-1500 ohms/cc
      Section No. 3—soil resistivity above 1500 ohms/cc

c. From the above length and Table 8 determine the number of anode stations (of five anodes each) needed for each section of the line. Isolated lower resistivity sections which do not extend beyond one check-point, such as swamps or sloughs, need not be considered separately and may be combined with the higher resistivity sections adjacent to them. Wherever possible, however, anode stations should be located in these local resistivity sections, and in this case Table 9 should be used. This procedure will permit the use of larger but fewer anodes and thus will reduce over-all installation costs.

For any fractional part of a station arrived at from either Table 8 or 9 which is greater than 0.25, use the next larger whole number of stations; otherwise, drop the fraction.

TABLE 8
Length of Coated and Wrapped Pipe Line Per Magnesium Anode Station—(Five Anodes Per Station)

Soil Resistivity.....	50–500 ohms/cc	500–1500 ohms/cc	1500–4000 ohms/cc
Type of Anode Used.	(50 lbs. ea.)	(17 lbs. ea.)	(9 lbs. ea.)
Current Density on Pipe.....	.1 ma/Sq. Ft.	.01 ma/Sq. Ft.	.01 ma/Sq. Ft.
Life of Installation..	10 Years	10 Years	10 Years
PIPE SIZE	Length of Pipe in Ft./Anode Station	Length of Pipe in Ft./Anode Station	Length of Pipe in Ft./Anode Station
4".....	12,000	41,100	22,100
6".....	8,200	28,000	15,000
8".....	6,300	21,400	11,600
10".....	5,000	17,200	9,300
12".....	4,300	14,500	7,800
14".....	3,900	13,200	7,100
16".....	3,400	11,500	6,200
18".....	3,000	10,300	5,500
20".....	2,700	9,300	5,000
22".....	2,500	8,900	4,500
24".....	2,300	7,700	4,100
30".....	1,800	6,200	3,300
36".....	1,500	5,200	2,800

TABLE 9
Length of Coated and Wrapped Pipe Line Per Magnesium Anode Station
(Where anodes are located in local areas of lower soil resistivity, five anodes per station.)

Soil Resistivity Along Line, Ohms/cc.....	500–4000	1500–4000
Soil Resistivity at Station, Local Area.....	50–500	500–1500
Type of Anode Used.....	50-lb.	17-lb.
Current Density on Pipe, ma/Sq. Ft.....	0.01	0.01
Life of Installation, Years.....	10	10
PIPE SIZE (Inches)	Length of Pipe in Ft./Anode Station	Length of Pipe in Ft./Anode Station
4.....	*	41,100
6.....	*	28,000
8.....	*	21,400
10.....	*	17,200
12.....	43,000	14,500
14.....	39,000	13,200
16.....	34,000	11,500
18.....	30,000	10,300
20.....	27,000	9,300
22.....	25,000	8,900
24.....	23,000	7,700
30.....	18,000	6,200
36.....	15,000	5,200

* A five-anode station of 50-lb. anodes is not practical for these line sizes.

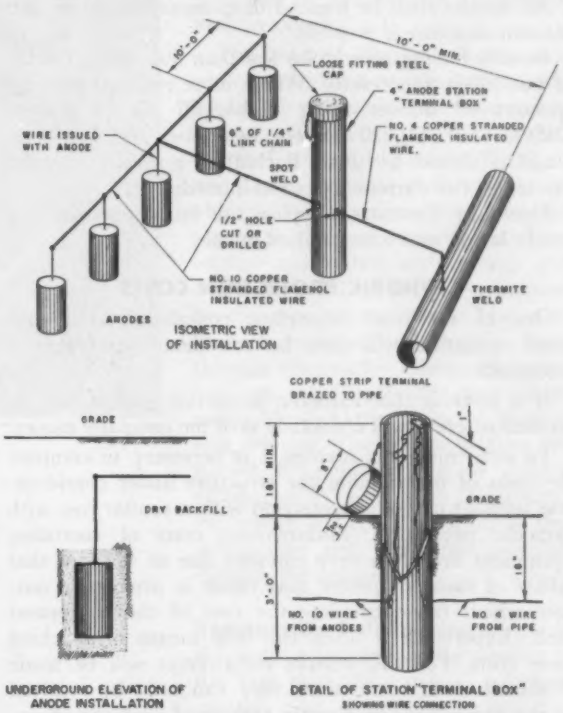

FIGURE 14—Typical soil installation showing anode layout and terminal box details.

Anode design cannot be considered an exacting science and anode station currents can be expected to vary widely from the desired value, but this matter has been considered in the preparation of the design chart and ample safety factors have been applied to cover these expected variations.[1]

The life of an anode installation is determined by the anode current output. The maximum anode current output for a ten-year life expectancy is given in Table 10.

If the current output of any anode station (of five anodes each), after allowing about two months operation to stabilize conditions, should exceed the value given in Column 3, Table 10, a nichrome wire resistor is to be installed in the anode lead wire in the station box to restrict the current to the desired value.

[1] Many modifications to the standardized procedure just described may be incorporated to fit local conditions. The above procedure was presented in detail in order that it might serve as a pattern for the corrosion engineer who is setting up his own procedures.

TABLE 10

Anode Weight, Pounds	Maximum Current Per Single Anode for 10-Year Life	Maximum Current Per 5-Anode Group for 10-Year Life
9	52 ma.	260 ma.
17	97 ma.	535 ma.
50	235 ma.	1.41 Amps.

Installation Procedure. All anodes should be planted on 10-foot centers (where possible). The minimum distance between pipe line and anode shall be 10 feet except when existing conditions or available space make such spacing impossible. In such cases, anode spacing will have to be adjusted to fit the existing conditions.

All anodes shall be planted deep enough to be in permanent moisture if possible.

In soils having resistivities less than 500 ohms, the use of backfill is unnecessary. Where more resistant soils are encountered anodes using a backfill of 75 percent $CaSO_4 \cdot 2H_2O_2$, 20 percent Bentonite, and 5 percent Na_2SO_4, should be used. Backfill is generally installed dry unless full current is desired immediately.

Figure 14 illustrates a typical soil installation showing anode layout and terminal box details.

CATHODIC PROTECTION COSTS

One of the most important considerations of any plant operation will now be considered—and that is economics.

It is obvious that cathodic protection should only be applied where it will ultimately save the company money.

To determine this savings it is necessary to compare the costs of maintaining the structure under consideration without cathodic protection with a similar cost with cathodic protection. Maintenance costs of corroding equipment are often very complex due to the fact that failure of such equipment may result in production outages which far outshadow the cost of the equipment itself. Experience is often the only means of reaching these costs. For this reason, no attempt will be made to discuss such costs, since they can only be resolved by the person who is directly concerned with the equipment in question.

This discussion then, will be confined to the development of a simple procedure whereby cathodic protection costs may be estimated. It will also be confined to situations where magnesium anodes are used as the current sources for cathodic protection.

In general, it may be said that the costs of the cathodic protection will depend on the following variables:

1. The quantity of current required per unit of surface area of the structure being protected.
2. The type of installation involved (soil, seawater, weight of anode, method of attachment, etc.).
3. Over-all size of installation.

The unit cost of the magnesium and the installation costs have been assumed to be constant, regardless of the size of installation. It is obvious, however, that in actual practice these costs will definitely vary with the size of the installation. Table 11 has been prepared for the purpose of illustrating how costs may be unitized in order to simplify cost estimation of field installations. The unit costs shown are not necessarily representative of actual conditions but are presented for illustrative purposes only.

Cost estimates can be made only after the installation has been designed, since it is necessary to consider design data in making the calculations as the following formulae will illustrate:

Total Costs. Total cost of protection = Total current needed in ma. x total cost per ma. per year for particular type of installation made. (Factor 'K' in table) x Life of Installation in years.

Example: It is desired to estimate the cost of a pipe line installation in which the current requirement will be 20 amperes and the life of the installation is to be 5 years. What will be the cost? Total cost = 20 x 1000 x .02 x 5 = $2000.

Cost Per Unit Surface. Occasionally it is desirable to arrive at a cathodic protection cost in terms of cents per square foot protected. This figure is useful in comparing cathodic protection with coating costs or possible substitution of a more noble metal. To arrive at this figure, the following formula is used: Cost of protecting one square foot of surface per year = current demand per square foot x 'K'.

Example: It is desired to estimate the cost per square foot of protecting an under water surface of steel piling. The current demand of this structure is estimated to be 3 ma. per square foot. What is the annual unit cost of the cathodic protection? Total cost per square foot per year = 3 x 0.018 = $.054.

It must be borne in mind that the above method of cost estimation results in only a rough approximation since many variables—such as weather, adverse working conditions, remoteness from headquarters, etc.—can materially affect the actual on-the-job costs.

TABLE 11
Cathodic Protection Costs with Magnesium Anodes

	Pipe Lines (Soil)	Steel Piling (Seawater)	Condenser Boxes and Screens (Seawater)	Internal Seawater Lines
Ratio of Installation Cost to Metal Cost*	1.7	1.3	1.3	1.5
Metal Cost/ma. Year†	.01	.01	.01	.01
Installation Cost/ma. Year	.010	.008	.009	.009
Total Cost/ma./Year ('K')	.02	.018	.019	.019

* Installation costs involve all costs relative to the job, exclusive of the cost of the metal itself. Contractor's or plant overhead and lost motion on the job are included. Engineering and inspection costs are not included.
† Based on a metal cost of $0.55 per pound.

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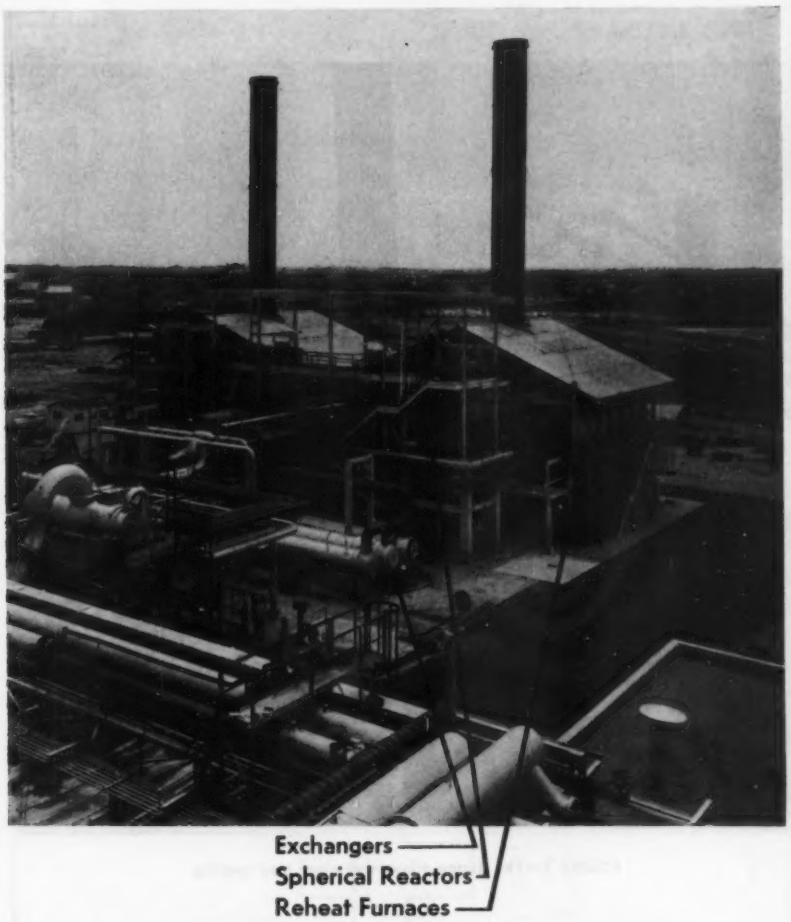

FIGURE 1—Reforming unit with spherical reactors.

Reactors Can 'Float' . . . On Ball Bearings!

Here's a unique system of design that minimizes the amount of alloy piping necessary for flexibility between reactors and heaters.

Edward P. Owen
The Fluor Corporation, Ltd., Houston

Socony Mobil Oil Company, Inc., went on stream at its Paulsboro, N. J., refinery in 1956 with a Socony-designed catalytic reforming unit which is believed to be the largest commercial unit of its type ever constructed. The unit, which will increase the refinery output of high octane fuels, has a nominal charge capacity of 20,000 barrels per stream day and consists of a catalytic reformer section and a naphtha pretreater section.

Several interesting structural features were incorporated into the design of this unit as a means of achieving economy of materials. As an example, spherical reactors mounted on ball bearings were used in the catalytic reforming section. The spherical shape of the reactors, as opposed to a cylindrical form, was chosen by Socony Mobil as a means of using the minimum amount of materials in the vessel shell and lining. The discussion in this article, however, will be confined primarily to the utilization of the movable supports and the problems of design that were involved.

The heart of the catalytic reformer section lies in the recycle system, consisting of a recycle gas compressor, reactor effluent charge exchangers, one preheat and two reheat furnaces, and three spherical reactors. Desulphurized naphtha from the pretreater system is pumped into the reformer section and mixed with recycle gas drawn from a high-pressure separator by the recycle compressor. The mixture of naphtha and recycle flows through the reactor charge exchangers into the first heater and alternately through the series of heaters and reactors. The effluent is then returned through the reactor charge exchangers to coolers and the separator, where liquid is drawn off to the debutanizer and the vapor recycled through the compressor.

Reactors On Ball Bearings. One of the unique features of the project is the fact that the catalytic reformer reactors and charge exchangers are mounted on ball bearings and thereby float freely within the recycle piping system. (See Figure 3) The idea of enabling the reactors to move freely was first advanced by Socony Mobil in the initial job instructions, as a means of minimizing the amount of alloy piping necessary for flexibility between the reactors and heaters. The piping in this area consists mainly of 18-inch O.D., 1-inch wall thickness, chrome-moly steel at an average temperature of 1000 F. The reactors are 13 feet in diameter, spherical in shape, weighing approximately 75 tons each and supported by a circular skirt and base ring.

Advantages and Disadvantages. After making a study of the piping layout, several advantages and disad-

Reactors Can 'Float'. . .

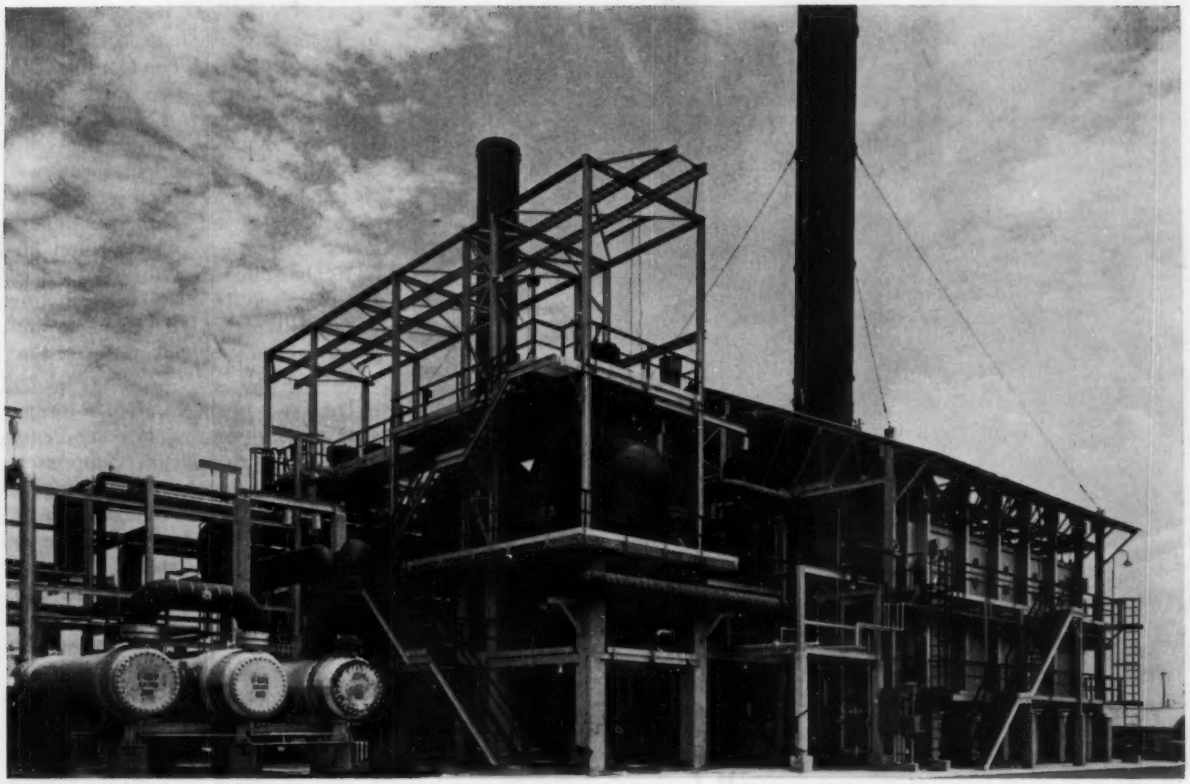

FIGURE 2—The design allows very close pipe spacing.

About the Author

EDWARD P. OWEN is principal designer for The Fluor Corp., Ltd., Houston, where he is head of the Structural Department. Owen received his B.S. degree in chemical engineering from Georgia Institute of Technology in 1943, and his M.S. degree from the University of Texas in 1948. He spent more than three years with the Corps of Engineers during World War II, then he joined Walter P. Moore, Consulting Engineer, Houston, as a structural engineer where he spent the next four years. He has been with The Fluor Corp. for five years.

vantages of floating reactors became evident. The advantages were as follows:

- The reactors and heaters could be placed very close to one another to fit the tight space requirements within the battery limits.
- The alloy piping between the heaters and reactors could be held to relatively short straight runs and a minimum amount of pipe and fittings.
- The pressure drop through the recycle system could be held to a minimum with resultant savings in the size of the recycle gas compressor.

The main disadvantages were:

- Anchors would have to be placed at the heater nozzles to protect the heater tubes from the reactions of the stiff piping between the heaters and reactors.
- The reactor nozzles would have to be reinforced to take the same reactions.
- The additional expense of the ball bearing assemblies.

After careful consideration, the conclusion was reached that greater advantage would be gained by letting the reactors move freely; and to further reduce the pressure drop and the amount of alloy piping, the reactor charge effluent exchangers were also mounted on ball bearings and allowed to "float."

Several new problems were now introduced by this move. Total movement in the piping system from heaters to exchangers was rather large (seven inches). In order to protect the compressor and other equipment, the movement in the entire exchanger-heater-reactor system generated by thermal expansion, other than that absorbed by natural flexibility, was designed to be taken by loops in the carbon steel piping between the charge exchangers and the recycle gas compressor. Provisions also had to be made for anchoring the exchangers

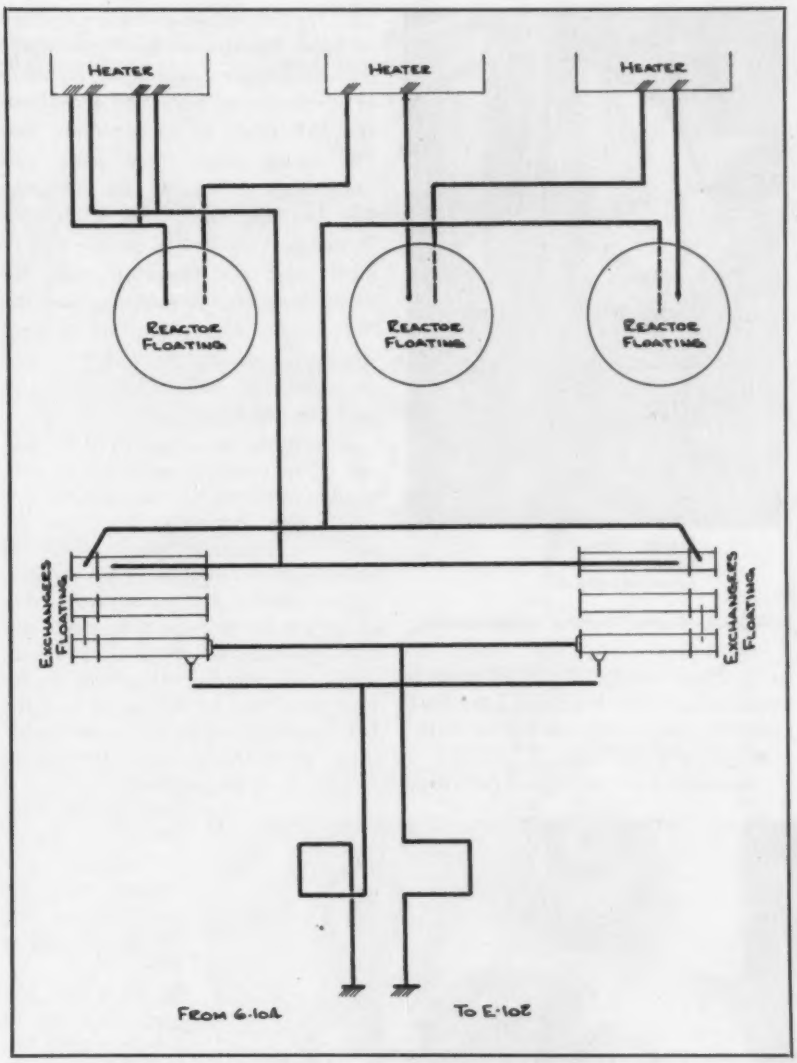

FIGURE 3—Reactors and exchangers float freely within the recycle piping.

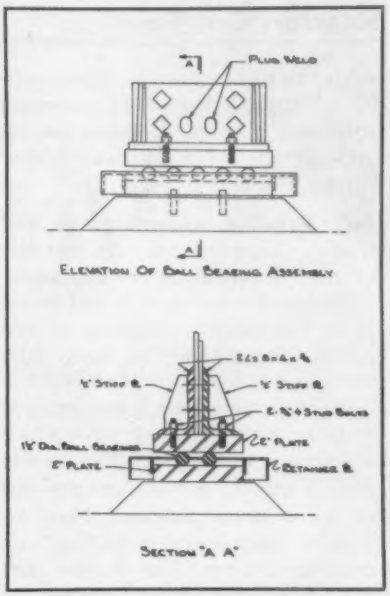

FIGURE 4—Elevation and section of reactor ball bearing assembly.

FIGURE 5—Ball bearing assembly has slip and bearing plate welded to the reactor's skirt.

during shut-downs when it was desired to pull the tube bundles.

Piping Stress. In addition to the above problems, the piping stress analysis became rather complicated with the placing of the exchangers on ball bearings. Some of the lines now ran from heater to reactor to the exchangers to the compressor without any such normal restraints as equipment anchorage. These lines were subject, though, to frictional forces, expansion forces, and opposing forces from other piping pushing on the same floating reactor or exchanger. However, it was felt that the pipe stresses were not too critical because if the reactors and exchangers did not "hang up" but moved freely, the system would seek the point of lowest stress as far as the pipe was concerned. The pipe itself was so stiff that it could withstand large total stresses. It was desired to obtain some idea of the range of these stresses though, and to ascertain as closely as possible the forces and moments on the heater anchors, reactor nozzles and exchanger nozzles. Some idea of the magnitude of the equipment movements also had to be obtained.

The pipe stress calculations used followed the Kellogg-derived equations for piping systems in three planes subjected to thermal expansion. Two methods were employed in using these calculations to solve the systems involved. The first method was a sequence of successive approximations. It involved calculating the pipe reactions at the moving equipment as though the equipment were anchored, then releasing the anchor, approximating the deflection, and successively calculating the resulting reactions from the piping until the forces from all piping connected to that particular piece of equipment were balanced.

The second method used was a more rigorous analysis, conforming to the Kellogg pattern. A particular pipe system was analyzed from rigid anchor to rigid anchor, treating the reactor as an infinitely stiff part of the pipe, free to rotate in the horizontal plane but restrained from tipping or deflecting in the vertical by external forces.

This method could only be used for the heater-reactor systems, however, as it became too cumbersome when extended through two points of re-

straint to the compressor. The results of the two methods were compared with each other for the same systems and agreed with each other within reasonable limits.

Ball Bearing Assembly. A ball bearing assembly for the reactors (Figure 4) consists of two clip angles welded to the reactor skirt and bolted to a "sandwich" consisting of two plates, each two inches thick, with eight 1½-inch diameter ball bearings between them. The bearings are held in place with a retainer plate which also retains a lubricant. The bottom plate is grouted in place and doweled to the concrete structure. Four assemblies, each carrying 19 tons, are used per reactor. The reactor skirt spans from assembly to assembly.

Rollers, self-lubricated plates, and ball bearings were considered as a means of enabling the reactors to move freely. Ball bearings were selected because of their minimum frictional resistance and the necessity for movement in two planes. It was decided to harden the surface of the plates riding on the bearings to prevent the balls from indenting the plates more than .002 inch.

Ductile iron with an ultimate strength of 80,000 psi was chosen for the plate material after considering several alternates, because of its corrosion resistance, toughness and castability. Grade 80-60-03 conforming to ASTM Specification A-339-51T was used. The plate bearing surfaces were flame hardened to a Brinnell hardness of 500 and ground smooth, with the base hardness not to exceed 270 Brinnell. Tool steel ball bearings with a crushing strength of 225,000 pounds were used for the bearings. They were packed with a lubricant and a corrosion preventive grease.

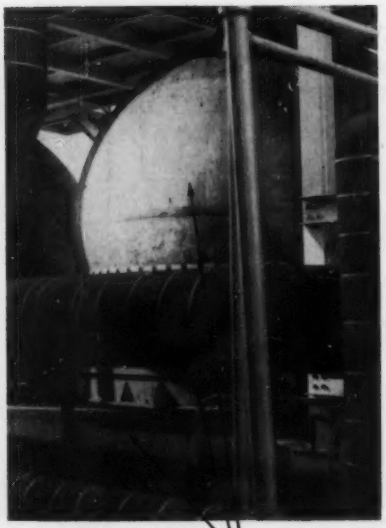

FIGURE 6—Reactor "floating" on ball bearings.

A similar ball bearing assembly was used for the charge exchangers which weighed approximately 25 tons each. The exchangers, connected in banks of three, are supported by a continuous WF beam at each saddle. The WF beam spans three piers, one under each exchanger, and rides on a ball bearing assembly at each pier. A bumper was bolted to the end of each pier, and provision made for shims between the bumpers and the WF beam. The shims are utilized during shutdowns, when it is desired to anchor the exchangers in order to pull the tube bundles.

During the development of the layout of the naphtha pretreater section, similar problems to those already discussed were encountered. It was desired to minimize the amount of stainless steel piping between the pretreater reactor and an adjacent bank of five exchangers and condensers and also to meet existing space limitations. Two ball bearing assemblies, therefore, were used to support each of the five exchangers separately and enable it to move freely within the piping system. A similar assembly to the one used for the reactor effluent charge exchangers was devised with the exception of the ductile iron plates which were designed as only one inch thick due to a lighter load being supported. During the surface hardening of these plates, it developed that they would not take the heat treatment without excessive cracking because of their thinness. Speed treat carbon steel plates of 1¼-inch thickness were substituted and were hardened satisfactorily.

The Sovaformer unit was designed and engineered by the Fluor Corporation Ltd. at its Mid-Continent Division in Houston.

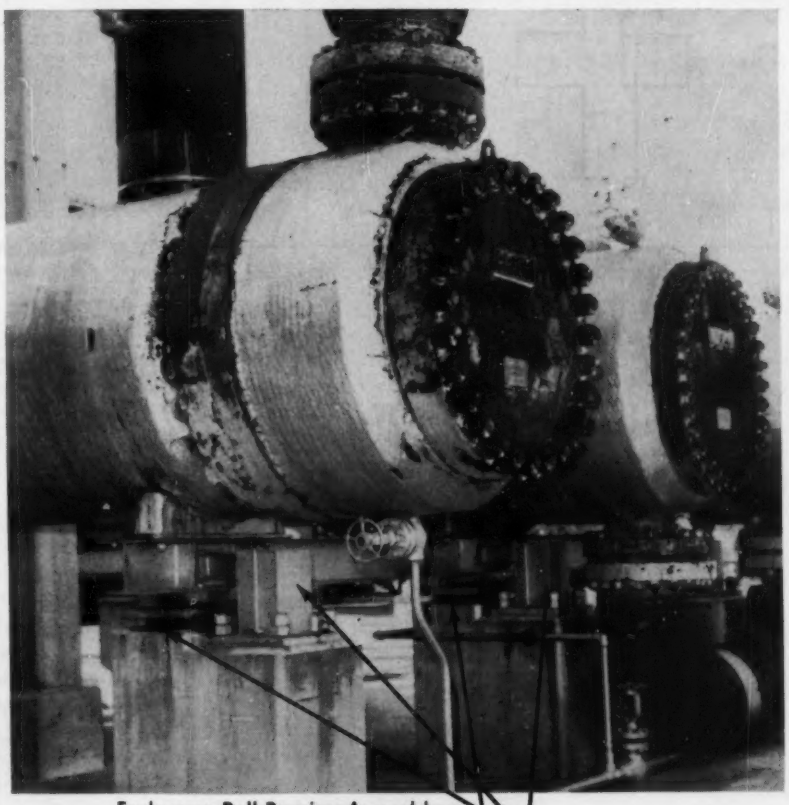

FIGURE 7—Exchanger ball bearing assembly and stops for removal of bundles.

Minimum Velocity for Catalyst Flow

Correlations to determine saturation carrying capacity and for the prevention of saltation (in horizontal tubes) and choking (in vertical tubes) are presented.

Frederick A. Zenz
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THE TECHNIQUE of fluid-solid flow is quite old. It would be assumed that it is well understood and defined. However, such is not the case. Study of the literature indicates that the design and development of pneumatic and hydraulic conveying systems is still an extremely empirical "art."

Numerous articles have described the mechanical features of conveying installations and some give at most recommended fluid velocities for specific granular materials. These velocities are nearly order of magnitude greater than velocities of interest in catalyst lines and similar chemical plant process carriers.

Only recently has there been any attempt made to develop general correlations for predicting the effects of variations in solids flow rate, velocity, particle characteristics, etc., on flow behavior or power requirements. In pneumatic transport it is, in many instances, not necessary to know pressure losses very accurately inasmuch as blowers are selected from standard catalogues and prices are not too dependent on small differences in blower size. On the other hand, the pressure losses and quantity of process fluid required for example in catalyst carrier lines, must be more accurately calculable since the permissable height of standpipe legs, process pressures, line sizes, solids circulation rates and erosion problems are all affected.

Other than the field of pneumatic conveying, the subject of particle-fluid flow has been widely investigated by civil and sanitary engineers. The elimination of unwanted sediment from drainage systems, the dredging of channels, the transport of coal in pipe lines, and the behavior and prediction of desert sand storms are typical problems requiring a fundamental knowledge of the laws governing this two-phase flow.

Part 3 will discuss the problems of saturation carrying capacity in fluid catalyst conveying systems. Minimum velocity to prevent saltation and choking are critical design factors. Part 2—"Find Best Particle Size Distribution," which appeared in the May REFINER, discussed the influence of particle size and distribution on fluidization. A quantitative treatment was developed which resulted in an equation for quickly determining the expected fluidization effects of variation in particle size.

One of the most perplexing aspects of the design of drainage systems involves the allowance to be made for the presence of sediments in the flow. Often undesirable but unavoidable accumulations of sediment reduce the capacity of a system by constricting the cross-section and thus also increasing the effective roughness of the pipe. Although in a given design case, the type, size distribution, and quantity of sediments, and the available hydraulic gradient are known, the effect of these variables on the performance is still in the stage of exploratory experimental investigation.

Several articles have appeared recently concerning fundamental studies of the conditions leading to impending particle deposition; the quantitative correlation of these data on liquid-solid systems with similar studies using gaseous fluid media has not as yet been fully resolved. However, the qualitative observations of the flow characteristics show a distinct similarity between gas-solid transport in a closed horizontal conduit and liquid-solid transport in either a closed conduit or an open flume.

Flow Characteristics in Horizontal Conveying. "Saturation carrying capacity" can be defined by considering a schematic graphical representation of data which could be obtained on a system in cocurrent fluid-solid flow in a horizontal pipe. A typical plot is given in Figure 1 which is a plot of pressure drop per unit length of pipe versus superficial fluid velocity with parameters of constant solids mass velocity. The line *AB*, labelled W=O, represents the Fanning friction loss for the fluid medium alone flowing through the pipe.

If, at the velocity corresponding to point *B*, a quantity of solids is introduced to the stream at a rate W_1, a rise in pressure loss (point *C*) between taps P_1 and P_2 will be noted due to the force required to maintain the solids in suspension and move them along with the fluid stream. The greater the solids flow rate (W_1, W_2, $W_3 - W_n$ indicate increasing solids flow rates) the greater the pressure loss.

Suppose now that at a particle rate W_1 the superficial fluid velocity is

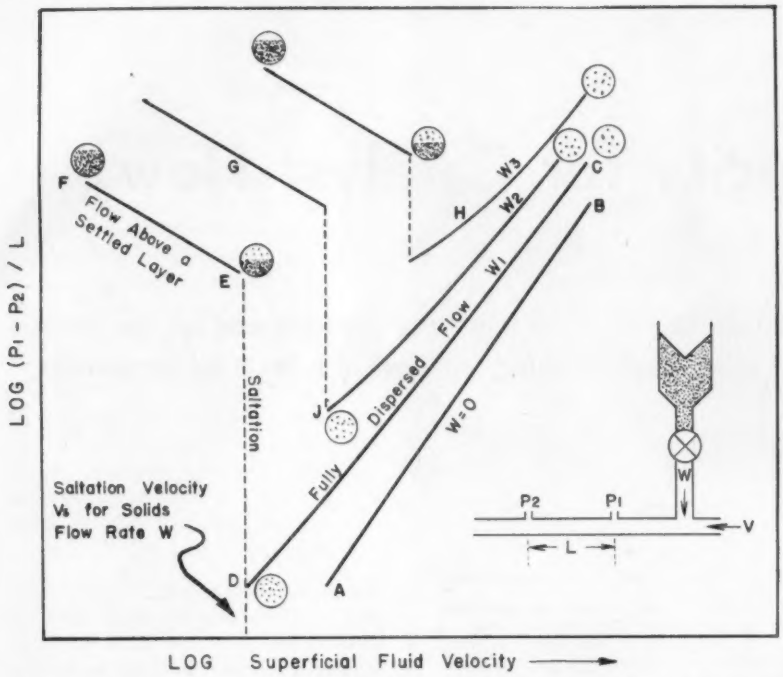

FIGURE 1—Schematic representation of fluid-solids flow characteristics in horizontal transport. Pressure drop per unit length of pipe is shown on the ordinate versus superficial fluid velocity on the abscissa. The parameters are lines of constant solids mass velocity, w, pounds per unit time per unit superficial pipe cross-sectional area.

slowly reduced from the value at point C to that at point D. Simultaneously the velocity of the particles will also decrease and the density or concentration of particles per unit length or volume of the tube will increase. Finally at point D, particles will begin to settle out in the bottom of the tube. The gas velocity at point D is called the saltation velocity; it is a function of W for any particular fluid-solid system. The solids rate, W_1, represents the saturation carrying capacity of the fluid at the velocity at point D. Similarly W_2 represents the saturation carrying capacity at the superficial velocity corresponding to point J.

When a saturation point is reached, and settling or saltation begins, there will occur an unsteady-state time period during which more and more particles settle out in the pipe and the pressure drop rises from the value at D to that at point E. At point E the depth of the settled layer of particles has reached equilibrium and the pounds of solids discharging from the pipe per unit time again equals the rate of solids fed at the inlet.

Obviously the time interval between the attainment of steady state conditions in going from D to E is a function of the solids rate W_1 and the length of pipe between inlet and discharge. The greater the pipe length the longer it will take to fill the equilibrium inventory; similarly the lower the solids rate the longer it will take to reach equilibrium. After an equilibrium layer of settled particles has been established, the steady flow of solids and fluid continues as a well dispersed mixture above the settled layer in the same manner as in flow at velocities greater than the saltation rate.

If the superficial fluid velocity is further reduced as from point E to point F in Figure 1, the settled layer of particles increases in depth; thus again an unsteady state period exists when either fluid or solid rates are changed. The time interval again depends on the magnitude of the system's inventory and the magnitude of the changes in flow rate.

This unsteady state period required to establish equilibrium must be carefully considered in the evaluation of data obtained on any system or operating installation in which transparent sections are not avaiable for observation of the flow conditions inside the pipe. Even in relatively small experimental apparatus transient periods up to four hours have been reported. The curves of Figure 1 are duplicated exactly when approached from low velocities less than the saltation rate. For example, as the gas rate is increased from F to E, the settled layer becomes shallower and shallower until at point E an unsteady state period again occurs until the settled layer is completely cleared from the pipe.

Many of the early research projects carried out in industrial laboratories concerning pressure drop in horizontal catalyst carrier lines were conducted in commercial iron pipe test loops. Many of these data were recorded during unsteady state periods; thus the resultant points might lead to curves giving values higher or lower than the corresponding steady states, depending on whether the conditions during the tests were changed in the direction from D to F, or from F to C, or F to G, or G to F (referring to the points in Figure 1).

The resultant data might lead to the conclusion that the curves appear

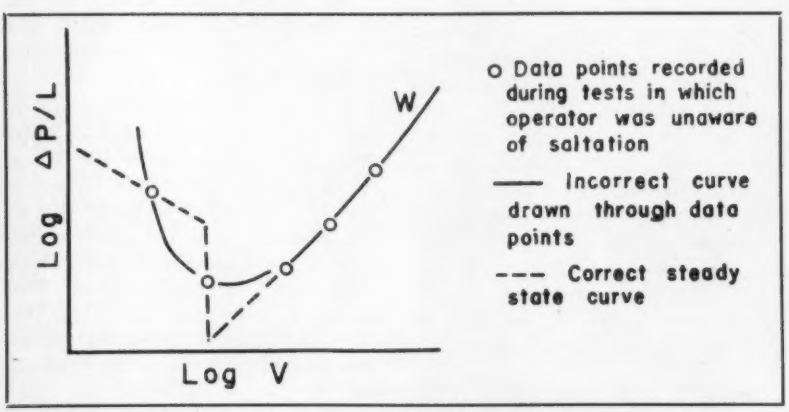
Log ΔP/L
W
Log V
o Data points recorded during tests in which operator was unaware of saltation
—— Incorrect curve drawn through data points
--- Correct steady state curve

FIGURE 2—Typical misinterpretation of horizontal transport data. The dotted curve represents the correct equilibrium steady state readings.

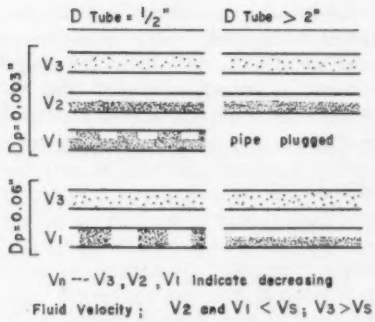

FIGURE 3—Effect of tube diameter on horizontal transport characteristics.

more nearly as shown in Figure 2 (where the dotted curve represents the correct equilibrium steady state readings). This is all the more a very natural mistake by analogy to the shape of the transport curves obtained in vertical flow. Careful experimentation in the saltation region has shown that there is no consistent tendency for material to begin settling out either at several or at any one particular point in a tube. It is suspected, however, that this settling velocity may be somewhat dependent on the characteristics of the inner surface of the pipe. Experiments with common iron pipe and with transparent plastic tubing have shown only slight differences in the measured saltation velocities, but if in an otherwise smooth tube there exists a rough spot, burr, or other minor obstruction, the saltation may preferentially begin at that point.

Most investigators who have reported saltation data for gas-solid systems have neglected to mention even semi-quantitatively the degree of saltation observed. The general conclusions of some are that when the saltation velocity is reached (point *D* of Figure 1) the particles begin to settle out and keep on settling out until the pipe is filled nearly half full (point *E* of Figure 1) before equilibrium is again established.

This has been observed with particles up to 0.11 inch in diameter in pipes larger than 1½ inch I.D. and with particles up to 0.006 inch in diameter in pipes as small as 0.5 inch I.D. In experiments with say 0.06 inch or larger particles in ½ inch I.D. tubes it is usually the case that the remaining open area above the settled layer is so small that when saltation occurs the flow pattern immediately becomes one of slug flow. This is best illustrated in Figure 3. Even with 60 micron particles in ½ inch tubes slug flow will eventually occur at high values of W or low values of the gas rate.

Experiments with 60 micron particles in ½ inch I.D. transparent plastic tubes showed that when slug flow did occur, the slugs moved only in the upper half of the tube above the stationary settled layer (see Figure 3).

In larger pipes of commercial interest, the flow conditions are best represented by the schematic cross-sectional sketches along curve *CDEF* of Figure 1. The particles that settle out in the pipe remain stationary. There is no rolling of the material or pushing of the entire layer through the tube, though a few of the particles on the surface of the layer are bounced along in the direction of gas flow. In the region *EF*, the steady flow of solids, W, occurs in the well dispersed solid-gas mixture flowing in the space above the settled layer of particles in the same manner as in flow at velocities greater than the saltation rate.

In civil engineering terminology, reference is made to so-called suspended-load transport and bed-load transport. The suspended load corresponds to that occurring above a layer of sediment as in the case of gas-solids flow. The bed load refers to the movement of the settled layer of sediment. In most instances, the bed load is small relative to the suspended load. In gas-solids systems the bed load is zero unless slug flow is established and then, of course, there no longer occurs any suspended load. In liquid-solid systems, the high viscosity of the fluid medium causes some net horizontal movement of the settled sediment under certain conditions.

Flow Characteristics in Vertical Conveying. Conditions of saturation carrying capacity, qualitatively similar to saltation and in certain instances quantitatively identical, are also encountered in vertical conveying. Saturation carrying capacity in a vertical transfer line can be defined by considering a schematic graphical representation of data which could be obtained in a two phase system in cocurrent upflow.

A typical plot is given in Figure 4 which again is a plot of pressure drop per unit length of pipe versus superficial fluid velocity with parameters of constant solids mass velocity. The line *AB*, labelled W=O represents the

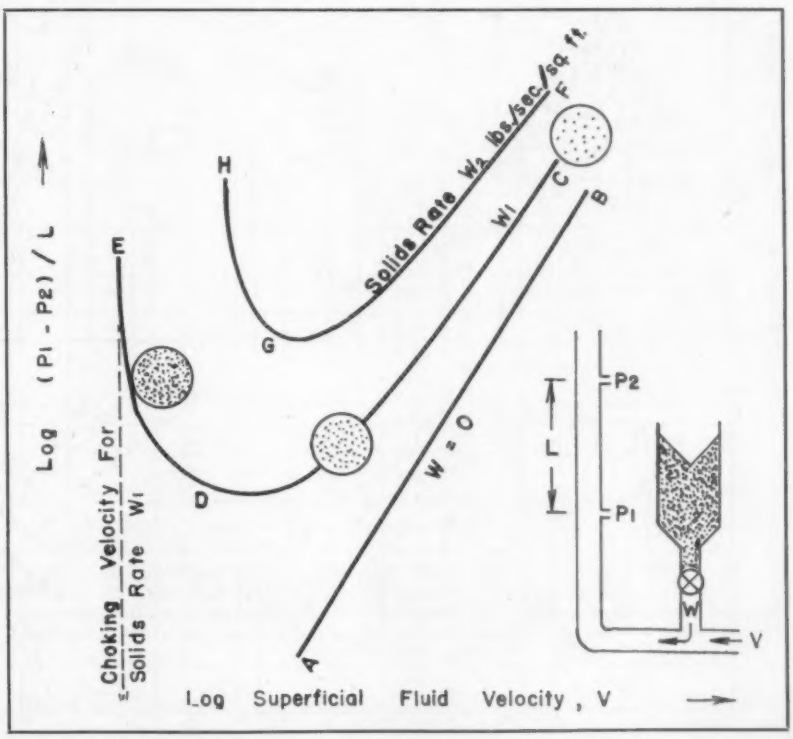

FIGURE 4—Schematic representation of Fluid-Solids flow characteristics in vertical transport. Pressure drop per unit length of pipe on the ordinate versus superficial fluid velocity on the abscissa. The parameters are the lines of constant solids mass velocity, W, pounds per unit time per unit superficial pipe cross-sectional area.

Fanning friction and head loss for the fluid medium alone flowing through the pipe.

If, at the velocity corresponding to point *B*, a quantity of solids is introduced to the stream at a rate W_1, a rise in pressure loss (point *C*) between taps P_1 and P_2 will be noted due to the additional force required to support the solids in suspension and move them along with the fluid stream. The greater the solids flow rate (W_1, W_2 — W_n indicate increasing solids flow rates), the greater the weight to be supported, and thus the greater the pressure differential.

Suppose now that at a particle rate W_1, the superficial fluid velocity is slowly reduced from the value at point *C* to that at point *D*. Simultaneously the velocity of the particles will also decrease and the density or concentration of particles per unit length or volume of the tube will increase. As point *D* is approached the fluid-to-tube-wall friction decreases and the weight of suspended solids inventory increases. At point *D* the solids head loss begins to exceed the fluid friction loss and further reduction in fluid velocity causes the pressure differential to rise again. As point *E* is approached, the solids velocity has decreased to such an extent that the fluid has difficulty in supporting the high flowing density of solids and eventually at point *E* the entire suspension collapses and is then transported up the tube in slug flow.

This collapse of the disperse flowing suspension into a condition of slug flow is referred to as choking. The solids flow rates at the choking points (*E* and *H* of Figure 4) represent the saturation carrying capacity of the fluid stream at the corresponding superficial velocities. Thus choking in vertical transport is somewhat analogous to saltation in horizontal transport; both phenomena represent *saturation* conditions in suspended or disperse phase flow.

Earlier a comparison was made between horizontal and vertical transport data obtained with the same systems in the same tube.[14] The experimental apparatus was so arranged that a portion of the transport tube upstream of the test section was replaced with a two-foot length of heavy wall gum rubber hose. This permitted orienting the test section at any angle to the horizontal. The data obtained in horizontal flow are compared with the vertical flow data in Figure 5. It is immediately apparent that over the range of these experiments the saltation velocities and choking velocities were identical for the uniform size particles. In other words, for a given solids mass velocity the air rate at which the vertical pipe choked was the same as the air rate at which saltation ocurred in horizontal flow. This was not observed in the experiments with the mixed size material. These data indicated saltation velocities 3 to 6 times as great as the choking velocities. This is in accord with numerous qualitative statements ap-

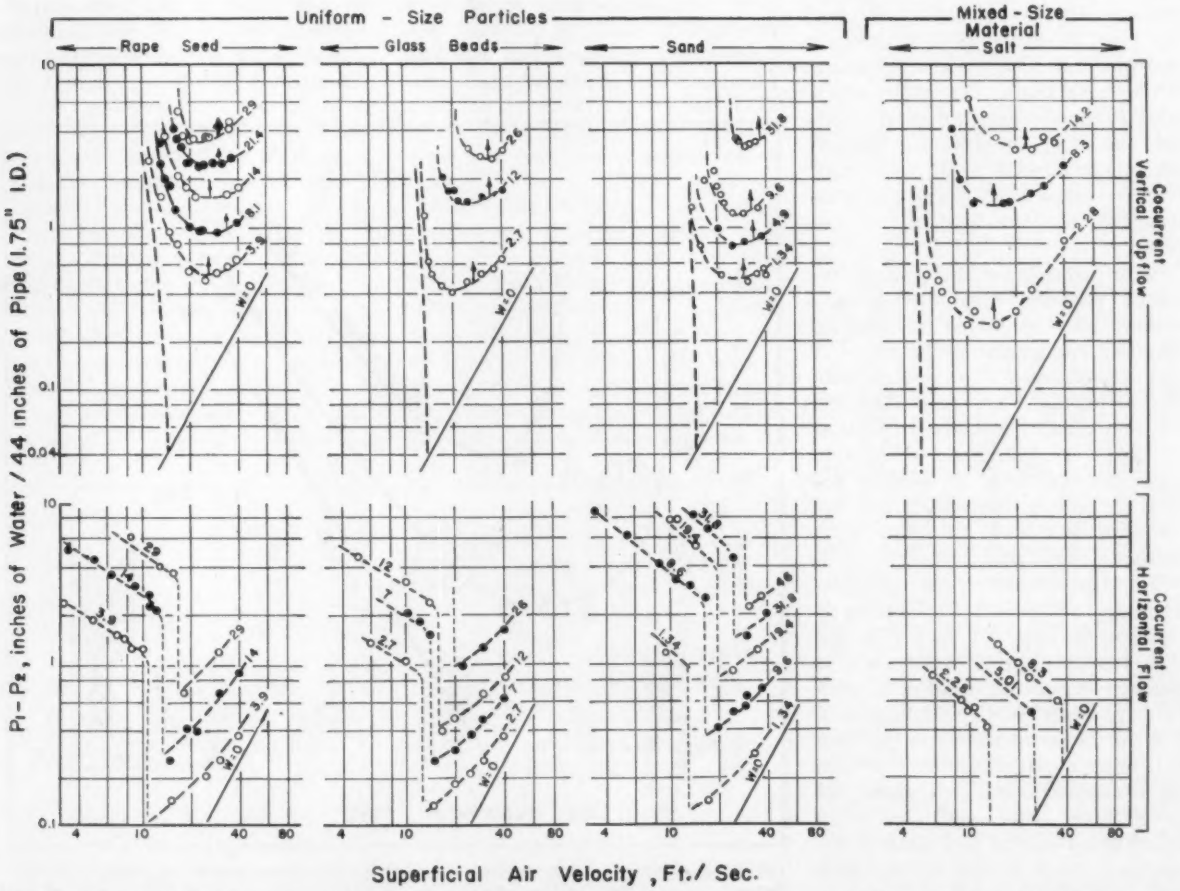

FIGURE 5—Experimental data on cocurrent Air-Solids flow. Horizontal and vertical flow are compared. Notice that over the range of these experiments that saltation velocities and choking velocities were identical for the uniform size particles.

pearing in the literature on pneumatic transport to the effect that the velocity required to convey materials horizontally is several times as great as that required to convey vertically.

Optimum Design Points. In the design of conventional pneumatic or hydraulic conveying systems, it is obvious that saltation in a horizontal run is to be avoided. However, from a power consumption or erosion standpoint, it is desirable to operate at as low a velocity as possible, i.e., as close to saltation as fluctuation in compressor performance, solids feed devices, or other operating variables will permit.

A similar situation exists in vertical flow where minimum power consumption and erosion (in some instances minimum attrition of solids) again calls for operation near the choking point. The theoretical optima occur in the vicinity of points *D* and *G* in the schematic representation of Figure 4.

A typical application occurs in the operation of air lift TCC units where operating instructions call for slowly reducing the primary transport air rate (after a fixed solids circulation has been established at the lift pot) until the onset of a slight surging in the lift leg is detected. The lift leg is generally in the neighborhood of 150 to 200 feet high and is tapered so that the velocity at the upper end is lower than at the bottom, despite expansion of the lift air due to temperature rise and pressure reduction. The surging condition therefore commences at the upper end and signals the approach to choking. If velocity were uniform along the length of the lift leg, choking would occur at an equal rate along the entire length and cause the contents of the lift leg to collapse to the bottom resulting in a forced shutdown until the fallen slug of catalyst is drained. Such operating upsets have occurred, despite precautions in overdesigning the taper, when zealous operators either fail to make sufficient practical allowance for fluctuations in air supply or increase the solids circulation without first increasing the primary lift air rate.

It is obvious that a correlation of

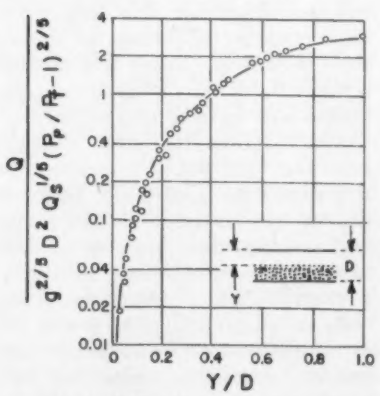

FIGURE 7—Ambrose' correlation for impending deposition or saltation.

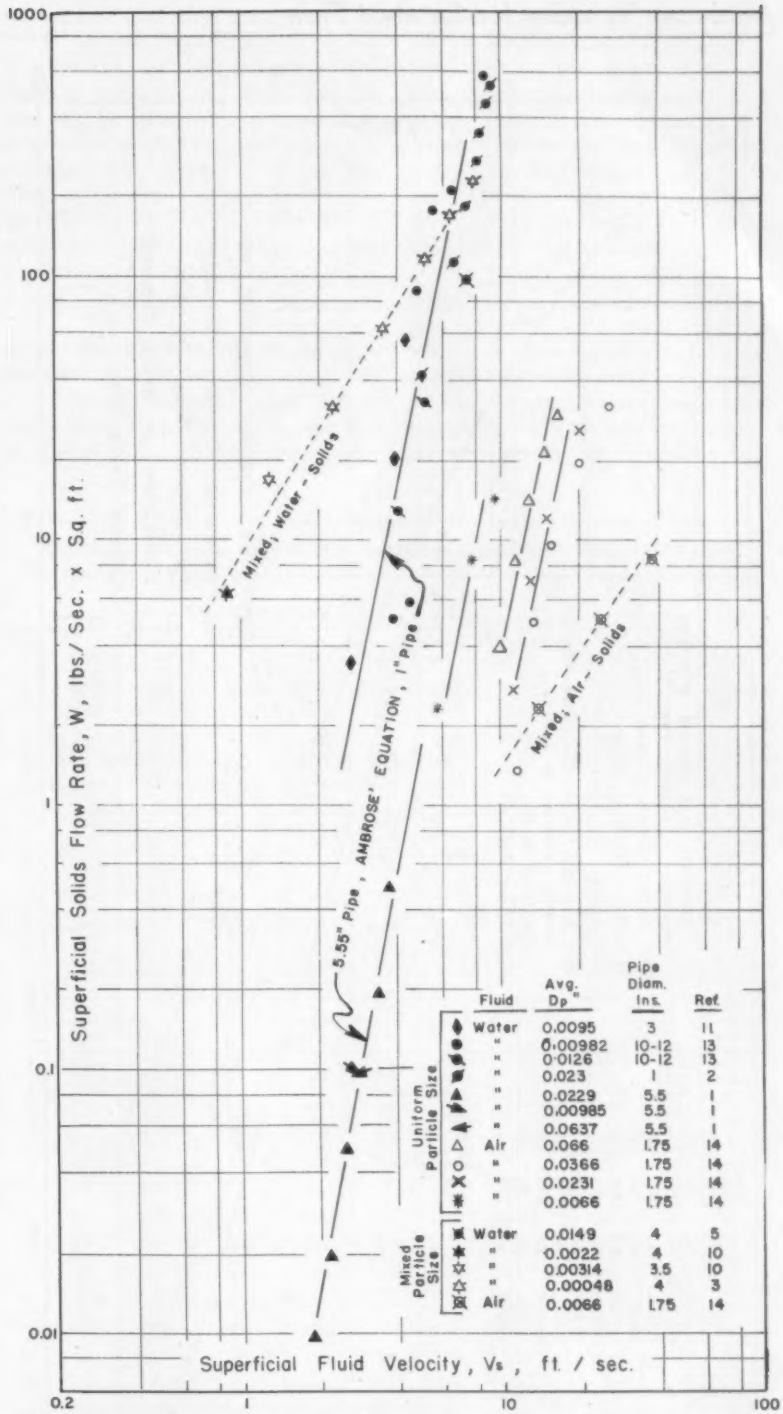

FIGURE 6—Experimental saltation data from various sources using both gaseous and liquid media. These qualitative conclusions may be drawn: 1. The slope of the curves for mixed size materials differs quite markedly from that for uniform size particles. 2. Not only is this difference noted with either gas or liquid as the carrying medium, but also the slopes for either medium are almost identical.

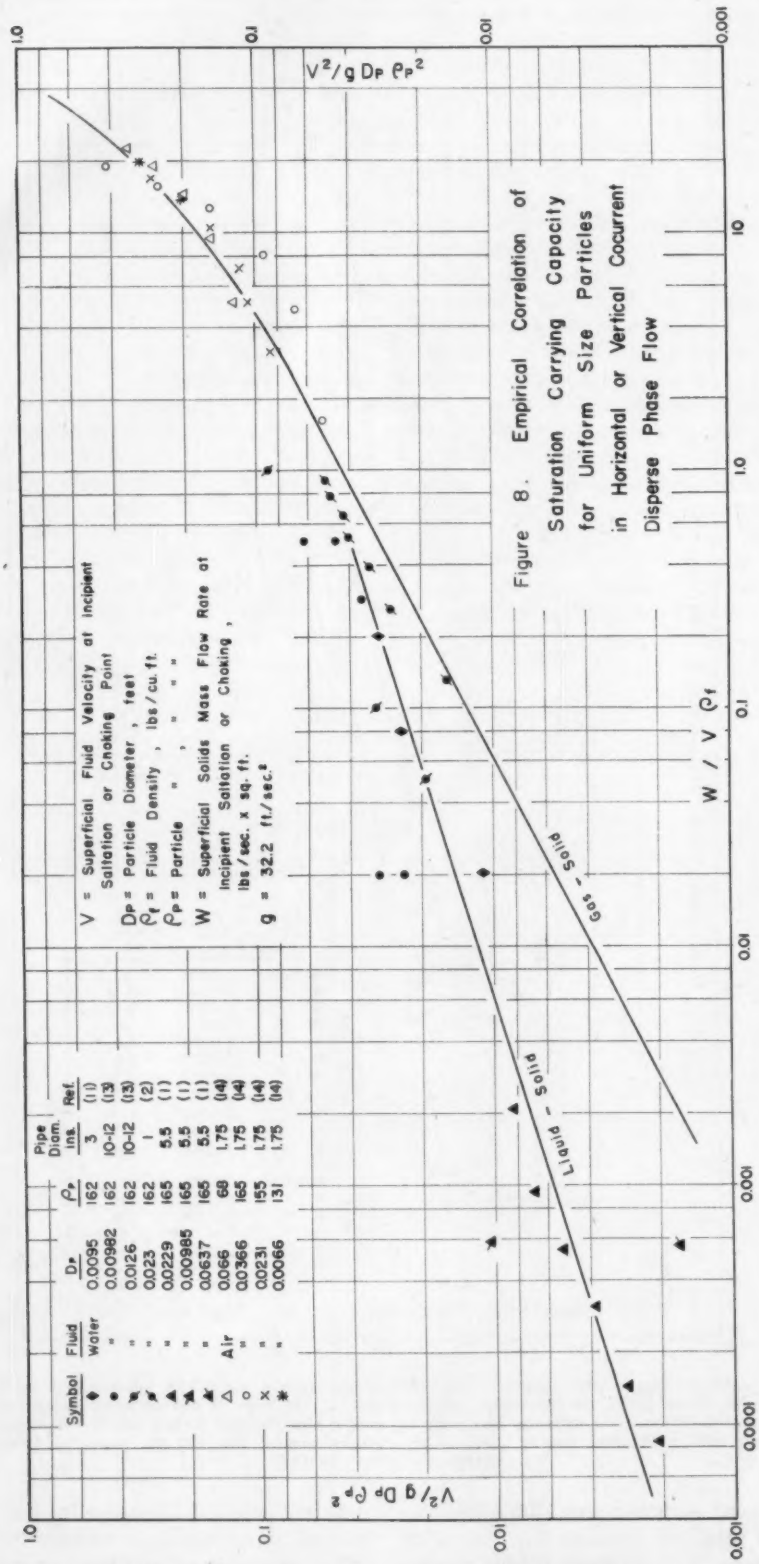
V = Superficial Fluid Velocity at Incipient Saltation or Choking Point
Dp = Particle Diameter, feet
ρf = Fluid Density, lbs/cu ft.
ρp = Particle " " "
W = Superficial Solids Mass Flow Rate at Incipient Saltation or Choking, lbs/sec. x sq. ft.
g = 32.2 ft/sec.²
Symbol | Fluid | Dp | ρp | Pipe Diam. ins. | Ref.
◆ | Water | 0.0095 | 162 | 3 | (11)
● | " | 0.00982 | 162 | 10-12 | (13)
■ | " | 0.0126 | 162 | 10-12 | (13)
▲ | " | 0.023 | 162 | 1 | (2)
▼ | " | 0.0229 | 165 | 5.5 | (1)
◀ | " | 0.00985 | 165 | 5.5 | (1)
▶ | " | 0.0637 | 165 | 5.5 | (1)
△ | Air | 0.066 | 68 | 1.75 | (14)
○ | " | 0.0366 | 165 | 1.75 | (14)
× | " | 0.0231 | 155 | 1.75 | (14)
✱ | " | 0.0066 | 131 | 1.75 | (14)
Gas - Solid
Liquid - Solid
V²/g Dp ρp²
W / V ρf
Figure 8. Empirical Correlation of Saturation Carrying Capacity for Uniform Size Particles in Horizontal or Vertical Cocurrent Disperse Phase Flow

FIGURE 8—This is the best empirical correlation finally obtained for the data on uniform size particles. Note that the air-solids data are in fairly good agreement.

saltation and choking phenomena would be very useful in design work. On the other hand, it should be mentioned that, if pressure restrictions do not exist, it is perfectly feasible to operate small diameter vertical lines in slug flow, e.g., at gas velocities below the choking point. Such operation will cause violent vibration in large diameter conduits due to the relatively large change in inventory as slugs are ejected, whereas in small diameter, relatively long lines, a fairly smooth transition from disperse flow to dense phase or mass lift operations could occur with slugging conditions going almost undetected.

Empirical Correlations. In recent years, several experimental studies bearing particularly on saltation in hydraulic conveying have been published, yet very few such data are available for gaseous transport media. In Figure 6 are plotted saltation rates obtained from various sources using both gaseous and liquid media. Despite the scarcity of data, it appears that some reliable qualitative conclusions may certainly be drawn.

1. The slope of the curves for mixed size materials differs quite markedly from that for uniform size particles.

2. Not only is this difference noted with either gas or liquid as the carrying medium, but also the slopes for either medium are almost identical. The data for sand-water systems cover a wide range of sand transport rates and show little, if any, effect of particle or pipe diameter.

The line drawn through the data of Ambrose[1] was calculated from his proposed equation for the minimum velocity required to prevent solids deposition in a full-flowing pipe. He studied the saltation phenomenon under both full and free-surface flow. The procedure consisted of setting the desired rates of sand and water flow through a horizontal 5.55 inch I.D. transparent plastic pipe inclined at a slope which would maintain the sand transport rate and then slowly decreasing the slope until the sand grains began to deposit. His correlation of the resulting data for three sizes of uniform sand (0.01 inch, .023 inch, .064 inch) is given in Figure 7. The value of the ordinate at y/D equal to one is 2.9, or, in other words, conditions of impending deposition under full flow can be represented by the relationship:

$$(Q/g^{3/5}\,D^2\,Q_s^{1/5}\,[(\rho_p/\rho_f)-1]^{2/5}) = 2.9 \quad (1)$$

where Q = cubic feet per second of fluid flowing
Q_s = cubic feet per second of solids flowing (absolute, not bulk cubic feet)
D = pipe diameter, feet
g = acceleration of gravity, ft./sec.^{2}
ρ_p = particle density
ρ_f = fluid density

This equation was used to calculate the curve drawn through Ambrose's data in Figure 6. Equation (1) can be rewritten in terms of V_s and W as:

$$\frac{V_s\,\rho_p^{1/5}}{W^{1/5}\,D^{2/5}\,[(\rho_p/\rho_f)-1]} = 3.51\,g^{2/5} \quad (2)$$

where V_s = saltation velocity, ft./sec.
W = solids transport rate, lb./sec. $\times$ ft.^{2}

Note that according to this equation the saltation velocity, at a constant solids mass velocity, W, varies as the 0.4 power of the pipe diameter, or:

$$\frac{V_s \text{ in } D_2}{V_s \text{ in } D_1} = \left(\frac{D_2}{D_1}\right)^{0.4} \quad (3)$$

Alternately at the same fluid velocity, V_s:

$$\frac{W \text{ in } D_2}{W \text{ in } D_1} = \left(\frac{D_1}{D_2}\right)^2 \quad (4)$$

For purposes of comparison, Ambrose's equation is plotted in Figure 6 for both 1-inch and 5.55-inch diameter pipe. It is interesting to note that his pipe diameter effect shows fair agreement with the data of Blatch,[2] but is in poor agreement with those of Yufin[13] and Smith.[11] In marked contrast to the air transport data the water experiments show no effect of particle diameter. However, the range of diameters investigated is rather limited. It hardly appears rational to suppose that no particle diameter effect exists, since in the extreme it is obvious that a higher water velocity would be required to convey 2-inch to 3-inch diameter stones as compared to ordinary beach sand. Correlation studies were therefore focused on the air-solids data.

Figure 8 presents the best empirical correlation finally obtained for the data on uniform size particles. Note that the air-solids data are in fairly good agreement. Since Figure 6 showed no particle diameter effect among the hydraulic experiments, better agreement with the correlants of Figure 8 cannot be expected. A tabulation of the data points comprising these figures is given in Table 1. The data of Figure 5 showed identity between saltation velocities and choking velocities, so that Figure 8 may also be considered to apply as a correlation of choking. As such it affords an opportunity to explore the effect of pressure, or gas density, in the absence of specific experimental investigations of this variable, through application to entrainment of solids from fluidized beds.

Application to Analysis of Entrainment. In the region immediately above the surface of a bed of fluidized particles, the bursting bubbles of fluidizing gas thrust particles upward in a fairly high concentration. As the majority of these particles (preferentially the larger ones) fall back down, onto the bed surface, the solids concentration decreases with distance above the bed. Simultaneously the puffs of gas from the bursting bubbles merge into a progressively more uniform flow profile. Eventually, at and above some particular height above the bed, the velocity profile approaches constancy and reference to a vessel superficial velocity is again significant and meaningful. Above this height, the rate of fallback of particles approaches zero, apparently only effected by position of particles relative to the fluid velocity

TABLE 1

Summary of Experimental Data on Saturation Dilute Phase Carrying Capacity

Source Reference	Fluid	Mean Particle Diameter Inches	Particle Density ρ_p, lbs/cu. ft.	Particle Size Distribution	Superficial Fluid Velocity V_s or V_{ch} ft/sec	Saturation Solids Rate w, lbs/sec. x sq. ft.	$\frac{W}{\rho_f V_s}$ or $\frac{W}{\rho_f V_{ch}}$	V_s^2 or V_{ch}^2 / $gD\rho_p$ or ρ_p^2	Pipe Diameter Inches	Cocurrent Direction of Flow
11.	Water	0.0095	162	Uniform	2.7	3.44	0.0204	0.011	3	Horizontal
11.	Water	0.0095	162	Uniform	4.0	20.0	0.0799	0.024	3	Horizontal
11.	Water	0.0095	162	Uniform	4.49	56.1	0.201	0.03	3	Horizontal
5.	Water	0.0149	162	Mixed	7.5	96.0	.....	.....	4	Horizontal
13.	Water	0.00982	162	Uniform	3.93	5.0	0.0204	0.0237	9.85	Horizontal
13.	Water	0.00982	162	Uniform	4.58	5.8	0.0204	0.0304	11.8	Horizontal
13.	Water	0.00982	162	Uniform	4.91	88.0	0.286	0.0351	9.85	Horizontal
13.	Water	0.00982	162	Uniform	5.56	173.0	0.50	0.045	9.85	Horizontal
13.	Water	0.00982	162	Uniform	6.55	205.0	0.50	0.0625	11.8	Horizontal
13.	Water	0.0126	162	Uniform	4.1	12.9	0.0505	0.019	9.85	Horizontal
13.	Water	0.0126	162	Uniform	5.24	32.6	0.10	0.0308	11.8	Horizontal
13.	Water	0.0126	162	Uniform	8.85	551.0	1.0	0.0887	11.8	Horizontal
10.	Water	0.0022	125	Mixed	0.9	6.24	.....	.....	4	Horizontal
10.	Water	0.00314	125	Mixed	1.33	16.9	.....	.....	3.5	Horizontal
2.	Water	0.023	162	Uniform	5.1	42	0.132	0.0155	1.0	Horizontal
2.	Water	0.023	162	Uniform	6.7	110	0.263	0.0267	1.0	Horizontal
2.	Water	0.023	162	Uniform	7.4	180	0.391	0.0326	1.0	Horizontal
2.	Water	0.023	162	Uniform	8.2	268	0.524	0.040	1.0	Horizontal
2.	Water	0.023	162	Uniform	8.4	341	0.65	0.0421	1.0	Horizontal
2.	Water	0.023	162	Uniform	9.0	440	0.785	0.0482	1.0	Horiosntal
2.	Water	0.023	162	Uniform	9.2	520	0.906	0.0506	1.0	Horizontal
3.	Water	0.00048	160	Mixed	2.3	31	.....	.....	4	Horizontal
3.	Water	0.00048	160	Mixed	3.6	63	.....	.....	4	Horizontal
3.	Water	0.00048	160	Mixed	5.2	114	.....	.....	4	Horizontal
3.	Water	0.00048	160	Mixed	6.5	165	.....	.....	4	Horizontal
3.	Water	0.00048	160	Mixed	7.9	228	.....	.....	4	Horizontal
1.	Water	0.0229	165	Uniform	3.75	0.485	0.00207	0.00836	5.55	Horisontal
1.	Water	0.0229	165	Uniform	3.36	0.193	0.00092	0.00675	5.55	Horisontal
1.	Water	0.0229	165	Uniform	2.95	0.098	0.000531	0.0052	5.55	Horisontal
1.	Water	0.0229	165	Unifrom	2.53	0.049	0.00031	0.00382	5.55	Horizontal
1.	Water	0.0229	165	Uniform	2.16	0.0193	0.0001435	0.00279	5.55	Horisontal
1.	Water	0.0229	165	Uniform	1.86	0.0097	0.0000831	0.00206	5.55	Horisontal
1.	Water	0.00985	165	Uniform	2.75	0.10	0.000581	0.0105	5.55	Horiosntal
1.	Water	0.0637	165	Uniform	2.8	0.097	0.000555	0.00168	5.55	Horisontal
14.	Air	0.066	68	Uniform	10	3.9	5.1	0.122	1.75	Horizontal and Vertical
14.	Air	0.066	68	Uniform	11.2	8.1	9.45	0.153	1.75	Horizontal and Vertical
14.	Air	0.066	68	Uniform	12.75	14.0	14.33	0.198	1.75	Horizontal and Vertical
14.	Air	0.066	68	Uniform	14.74	21.4	19.0	0.265	1.75	Horizontal and Vertical
14.	Air	0.066	68	Uniform	16.75	29.0	22.7	0.342	1.75	Horizontal and Vertical
14.	Air	0.0366	165	Uniform	11.7	1.34	1.62	0.0511	1.75	Horizontal and Vertical
14.	Air	0.0366	165	Uniform	13.4	4.9	4.78	0.067	1.75	Horizontal and Vertical
14.	Air	0.0366	165	Uniform	15.6	9.6	8.05	0.0909	1.75	Horizontal and Vertical
14.	Air	0.0366	165	Uniform	20.2	19.4	12.54	0.1525	1.75	Horizontal and Vertical
14.	Air	0.0366	165	Uniform	26.2	31.8	15.88	0.257	1.75	Horizontal and Vertical
14.	Air	0.0366	165	Uniform	33.6	48.0	18.8	0.423	1.75	Horizontal and Vertical
14.	Air	0.0231	155	Uniform	11.25	2.7	3.14	0.085	1.75	Horizontal and Vertical
14.	Air	0.0231	155	Uniform	13.0	7	7.05	0.1136	1.75	Horizontal and Vertical
14.	Air	0.0231	155	Uniform	15	12	10.45	0.1512	1.75	Horizontal and Vertical
14.	Air	0.0231	155	Uniform	20.2	26	16.83	0.274	1.75	Horizontal and Vertical
14.	Air	0.0066	131	Mixed	14.0	2.28	.....	.....	1.75	Horizontal
14.	Air	0.0066	131	Mixed	24.0	5.01	.....	.....	1.75	Horizontal
14.	Air	0.0066	131	Mixed	38.0	8.3	.....	.....	1.75	Horizontal
14.	Air	0.0066	131	Mixed	5.75	2.28	5.18	0.1085	1.75	Vertical
14.	Air	0.0066	131	Mixed	7.8	8.3	13.9	0.201	1.75	Vertical
14.	Air	0.0066	131	Mixed	9.6	14.2	19.3	0.303	1.75	Vertical

distribution in the flow profile. Therefore, conditions at such elevation may be interpreted as saturation vertical transport with the fluidized bed acting as the solids feeder.

W. G. May[7] and F. R. Russel of Esso Research and Engineering Company discussed the results of studies of the effect of high pressures on entrainment from beds of narrow cut and wide cut samples of FCC catalyst. Their data on a narrow cut sample are given in Figure 9, as presented by E. J. Gohr.[9] The solid curves are based on the experimental points; the dashed curves were computed from the empirical correlation of Figure 8.

The agreement is not exceptional but it does show rather well the proper order of the pressure effect. There is, of course, no assurance that the experimental data were taken at such distances above the bed where equilibrium would be anticipated. It is also probable that the narrow diameter of the test vessel (2 inches) may have reduced its efficiency as a solids feeder particularly at low pressures where approach to slugging conditions may have occurred. The application of Figure 8 to entrainment from fluidized beds of wide particle size distribution is too complex for development here, but results have shown excellent agreement with careful experimental measurements.

Correlation with Dilute Phase Fluidization. As the superficial gas velocity through a dense fluid bed contained within a relatively narrow diameter tube is increased, a velocity is finally reached at which slugging sets in. If the velocity is then still further increased till the voidage becomes rather high (conventionally within the range of 0.90 to 1.0), smooth disperse phase fluidization is again established.

The vertical air-solids upflow data of Table 1 indicate that the fluid velocity V_{ch} at which a solids mass upward flow, W, chokes the tube may be related to the superficial fluid velocity $V\varepsilon_s$ at which a disperse fluidized suspension begins to slug, by the equation:

$$W = \rho_p (1 - \varepsilon_s) (V_{ch} - V\varepsilon_s) \quad (5)$$

where W = solids upflow rate, lbs./sec. × sq. ft.
ρ_p = solids particle density, lbs./cu. ft.
V_{ch} = choking velocity, superficial ft./sec.
$V\varepsilon_s$ = superficial fluid velocity at which a disperse fluidized suspension begins to slug; approximately equal to the particles terminal or free fall velocity, ft./sec.
ε_s = minimum voidage in dilute fluidized suspension at the onset of slugging, cu. ft./cu. ft.

Equation (5) merely states that at the maximum or saturation disperse phase solids concentration the particles will have a velocity equal to the difference between the choking velocity and the velocity required to suspend them without transport. If this be the case, then it should be possible to compute the saturation concentration from the choking data and this concentration should then be a constant for each fluid-solid system.

In applying Equation (5) the value of $V\varepsilon_s$ must also be known for each system. In the absence of any data, this may usually be taken equal to the free fall or terminal velocity of the particles as a first approximation, unless a reliable fluidization correlation is available in this range. In general, $V\varepsilon_s$ will be smaller than the terminal velocity, thus making the first approximation conservative for design.

Table 2 presents a summary of the application of Equation (5) to the air-solids choking data of Table 1. The values of $V\varepsilon_s$ were obtained by trial and error and then checked against calculated terminal velocities. Note the relative constancy of ε_s for each system in Table 2; this lends some credence to the assumptions on which Equation (5) is based. Since choking V_{ch}, was found identical to saltation, V_s, for the range of uniform size particles investigated, Equation (5) offers simultaneously a means of predicting saturation suspended flow conditions in both horizontal and vertical lines for transport of narrow cut or uniform size particles.

Saturation disperse phase transport

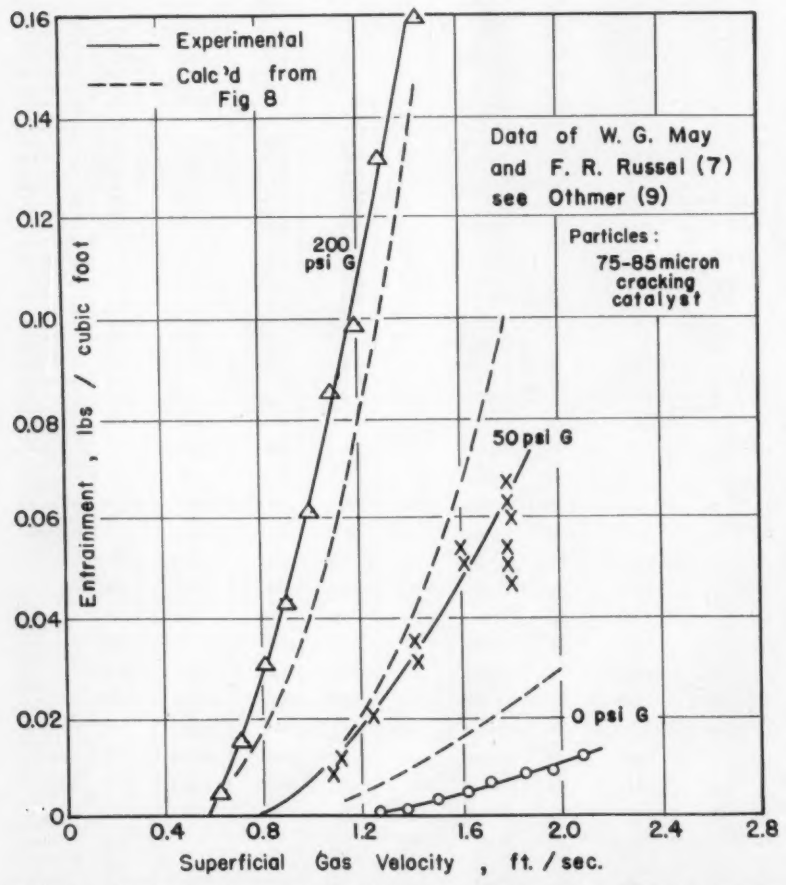

FIGURE 8—Calculated and experimental entrainment at various pressures. The solid curves are based on the experimental points while the dashed curves were computed from the empirical correlation of Figure 8.

rates cannot be computed from Equation (5) without knowing the value of ε_s for the particular system under consideration. Unfortunately very little data other than that presented in Table 2 is available for study. However, it is generally conjectured that ε_s is a function of particle diameter and the ratio of particle to fluid density of a form such as shown schematically in Figure 10. At low ratios of solid to fluid density, e.g., of the order of 3, particles of size D_{P_2} (referring to Figure 10) will show complete homogeneity over the entire voidage range from a packed bed ($\varepsilon=0.4$) to a single particle ($\varepsilon=1.0$), whereas larger particles, D_{P_3} will exhibit bubbles, or slugging in small tubes, between voidage of ε_1 and ε_2. At higher values of ρ_p/ρ_f, particles of size D_{P_2} will also show nonhomogeneity. Commercial gas-phase petroleum cracking processes and laboratory air fluidization experiments fall in the range of ρ_p/ρ_f of approximately 1200, with particle diameters of 60 to 3000 microns. The homogeneous liquid fluidization experiments, on the other hand, have ρ_p/ρ_f values of the order of 2 to 3. In Figure 10, ε_1 would correspond to the value of ε_s in Equation (5) for particles of size D_{P_3} whereas ε_2 would correspond to the onset of slugging as the superficial fluidizing velocity is increased through a dense bed of particles of size D_{P_3}.

Table 3 lists the few reported experimental observation of ε_s. These data are shown graphically in Figure 11 which is similar to the schematic representation of Figure 10. The observations reported in the low range of particle to fluid density ratio are, of course, insufficient to describe reliable curves. The data merely orient the particle diameter ranges very crudely.

Figure 11 is presented here mainly for its suggestive value for further study and experimental exploration. It also provides some indication of the particle and fluid density ranges which would have to be attained if improvements in the quality or range of homogeneity of any fluidized system were to be sought.

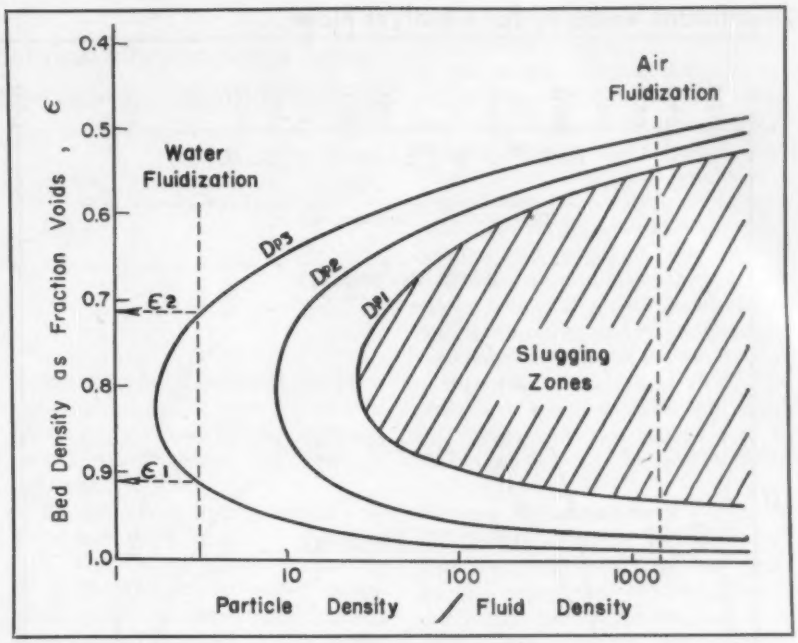

FIGURE 10—Schematic plot of effect of particle size and density ratio on slugging limits in dilute and dense phase fluidization.

Saturation by Particle Interference. The constancy of ε_s values calculated from transport data, as reported in Table 2, leads to further theorization as to the possible significance of saturation phenomena in terms of flow profiles within the suspension. For example, it is fairly well understood that an object submerged in a flowing fluid will generate a turbulent wake, the size of which will depend upon the size and shape of the object, and the properties and flow rate of the fluid. It is also a well established phenomenon that induced turbulence reduces the drag coefficient; in other words, a higher velocity is required to suspend a particle in a rising gas stream if turbulence is induced by some means such as passing the gas through a coarse screen located in the upstream flow. This effect of artificial turbulence is evident no matter what the superficial flowing Reynolds number may be on either tube or particle diameter basis.

If we now consider the immediate area of a wake as a small region of induced turbulence, a mechanism for saturation concentration becomes evident. Suppose for example that a very dilute concentration of particles is held in suspension by an upward flowing gas stream. The particles are spaced approximately 100 diameters

TABLE 2

Calculated Particle Concentrations in Saturation Disperse Phase Air-Solids Upflow According to Equation (5)

Particle Diameter Inches	W lbs./sec. x sq. ft.	ρ_P lbs./cu. ft.	V_{ch} ft./sec.	Ve_s ft./sec.	ε_s
0.066	3.9	68	10	9.0	0.9426
0.066	8.1	68	11.2	9.0	0.9459
0.066	14.0	68	12.75	9.0	0.9450
0.066	21.4	68	14.74	9.0	0.9452
0.066	29.0	68	16.75	9.0	0.9450
0.0366	1.34	165	11.7	11.07	0.9871
0.0366	4.9	165	13.4	11.07	0.9873
0.0366	9.6	165	15.6	11.07	0.9872
0.0366	19.4	165	20.2	11.07	0.9871
0.0366	31.8	165	26.2	11.07	0.9873
0.0366	48.0	165	33.6	11.07	0.9871
0.0231	2.7	155	11.25	10.25	0.9826
0.0231	7.0	155	13.0	10.25	0.9825
0.0231	12	155	15.0	10.25	0.9837
0.0231	26	155	20.2	10.25	0.9831
0.0066	2.28	131	5.75	4.89	0.9797
0.0066	8.3	131	7.8	4.89	0.9782
0.0066	14.2	131	9.6	4.89	0.9770

TABLE 3

Reported Observations of Dilute and Dense Phase Slugging Limits

Dilute Phase ε_s Limit	Dense Phase ε_s Limit	Particle Diameter Inches	Particle Density ρ_p, lbs./cu. ft.	Fluid Density ρ_p, lbs./cu. ft.	ρ_P/ρ_f	Reference Source
	Approx. 0.6	0.205	146	0.076	1920	6.
No slugging		0.205	146	62.4	2.34	6.
No slugging		0.174	100	62.4	1.603	6.
Slugging		0.15-0.33	875	62.4	14	6.
No slugging		0.125	9.2	0.35	26.2	4.
0.945		0.066	68	0.076	895	14.
	Approx. 0.7	0.0393	164	0.076	2150	6.
0.987		0.0366	165	0.076	2165	14.
0.983		0.0231	155	0.076	2040	14.
	Approx. 0.7	0.0201	156	0.076	2050	6.
	Approx. 0.8	0.011	156	0.076	2050	6.
0.978		0.0066	131	0.076	1720	14.

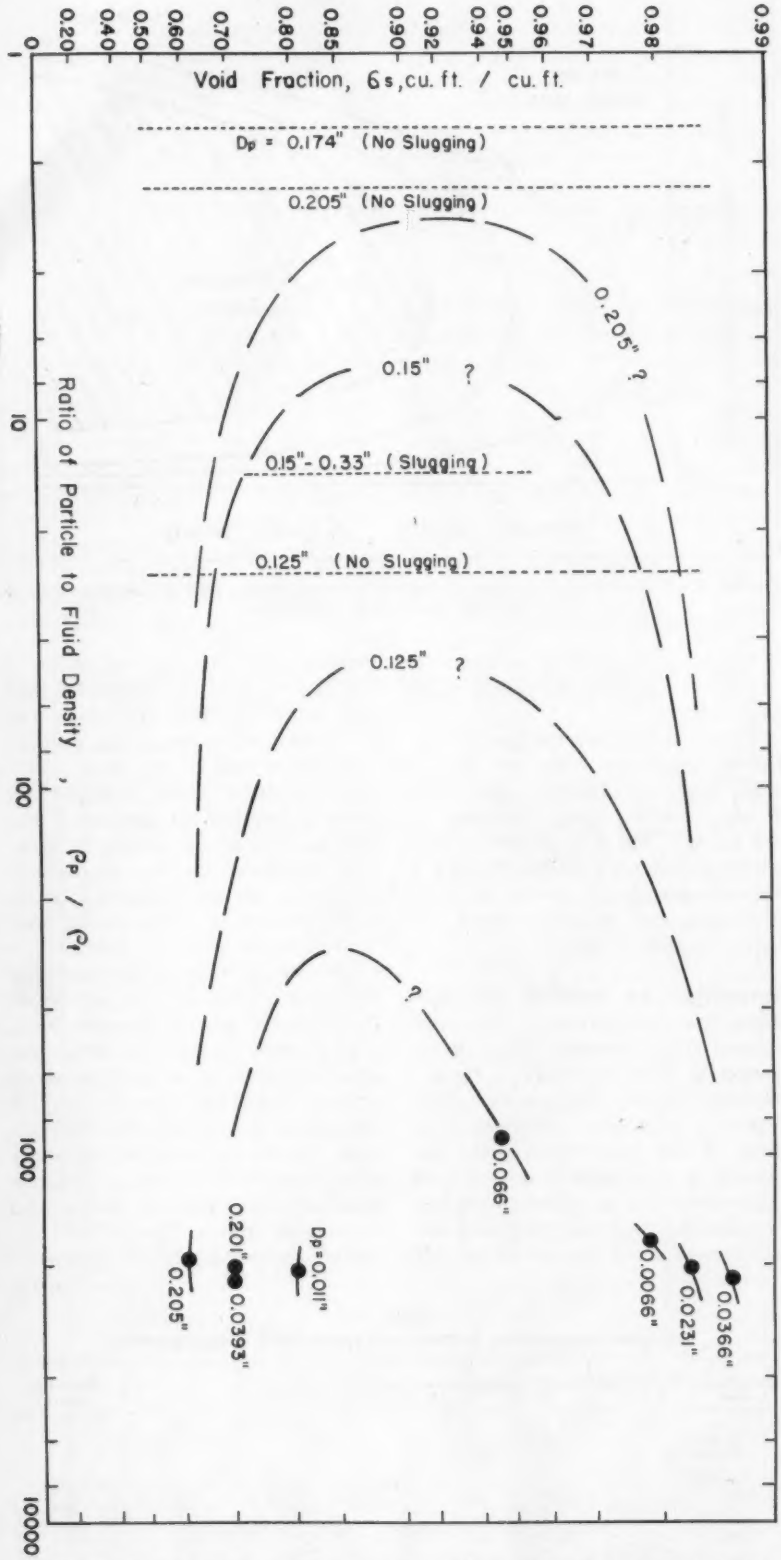

FIGURE 11—Some reported dense phase and dilute phase slugging limits in terms of voidage. This is a graphical presentation of the data in Table 3.

apart from each other and each is followed by a downstream wake length of 20 particle diameters. If an equal number of particles are added to the suspension to double the concentration, the particles will be spaced on the average of 50 diameters apart. If the concentration is increased up to five fold the particles will be spaced only 20 diameters apart and each particle will then just graze the tip of the wake trailing the next nearest upstream particle. Any further increase in particle concentration will require closer spacing and cause each particle to fall within the wake of its upstream neighbor. Once within the turbulent region of a wake the superficial velocity will not be sufficient to suspend the particle. It will therefore fall and touch its neighboring upstream particle. The two particles now present a larger effective diameter, so the superficial velocity will obviously be insufficient to maintain a suspension and the entire inventory collapses to the bottom of the vessel.

It would be somewhat premature to draw conclusions on the basis of such few data as exist. However, the data in Table 2 give computed particle spacings (assuming a cubic lattice) and Reynolds numbers, which are in excellent agreement with Reynolds number versus wake length information taken from the literature on hydrodynamics. It would seem highly enlightening to explore this phase of the subject experimentally on an academic level. Meanwhile resort must be made to an empirical approach, such as in Figure 8, for design estimations.

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Part 4 will appear in an early issue of ***PETROLEUM REFINER***

First Postwar Butadiene Plant

Texas Butadiene and Chemical Corporation's Lyondell plant is now on stream. The two major products will be aviation gasoline and butadiene.

W. J. Brack
Texas Butadiene and Chemical Corporation, Channelview, Texas

M. R. Beychok
The Fluor Corporation, Ltd., Los Angeles

THE FIRST butadiene plant built since World War II has gone on stream. The plant, owned and operated by the Texas Butadiene & Chemical Corporation of Houston is also the first privately financed butadiene plant in the nation. The $30 million plant is one of the latest additions to the rapidly expanding petrochemical industry centered around the Houston-Gulf Coast area. Designated as the Lyondell Plant of TB&C, and located on 410 acres of land adjacent to the San Jacinto River between Houston and Baytown, Texas, the plant was designed and constructed by The Fluor Corporation, Ltd.

Starting with *n*-butane and *iso*-butane as raw material feeds, the plant was designed to produce 64,800 tons per year of butadiene and about 2½ million barrels of high-octane aviation grade gasoline. Under an alternate mode of operation, the plant can produce 86,000 tons per year of butadiene for use in the synthetic rubber, textile, paint and chemical industries.

The processing area is basically divided into three areas.

1. The Dehydrogenation Area—using the Houdry Process Corporation[1] process to catalytically convert *n*-butane to butadiene and butylenes.

2. The Recovery Area—using the Phillips Petroleum Company's[2] process to separate and recover butadiene and the butylene-containing streams by furfural extractive distillation and conventional fractionation.

3. The Sulfuric Acid Alkylation Area—using the Stratford Engineering Corporation's[3] and the Texaco Development Corporation's process for converting fresh *iso*-butane and butylene-containing streams into light avgas and motor gasoline alkylate.

The original plant concept and evaluation of economic feasibility was initiated by the Purvin and Gertz consulting firm of Dallas in 1954. After the initial evaluation was made and financial backing was acquired. The Fluor Corporation was awarded the over-all contract in 1954. Fluor was responsible for the over-all design conceptions and details of plant layout, guarantee arrangements, process design in cooperation with licensors and design of utilities and offsite facilities.

Ground was broken for the start of construction in the fall of 1955. The plant was completed and the initial operating unit was turned over to TB&C personnel in December, 1956.

Process Arrangement. The three processes employed by TB&C have all been used individually and have commercial experience. However, this is the first instance where the three have been combined into one operating unit to produce two such diverse products as butadiene and aviation gasoline.

The ability of the dehydrogenation process to make butadiene and butylenes in one step from butane gives the plant its unique dual purpose capabilities. By using the furfural extractive fractionation process to separate butadiene from butylenes, an excellent butylene feed stock is obtained for alkylation.

The TB&C plant operation differs

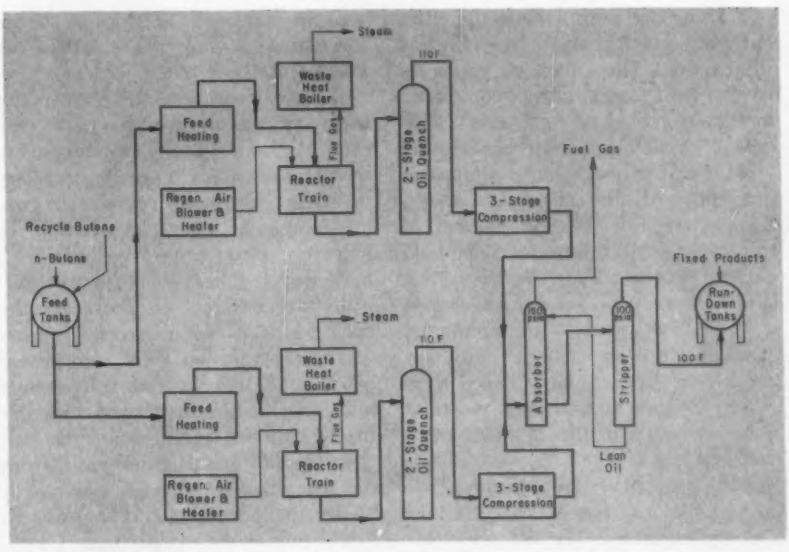

FIGURE 1—Schematic flow diagram of the dehydrogenation area. Notice that this area is split into two parallel trains to simplify maintenance and to permit flexibility of operation.

from other one-step dehydrogenation units in that it specifically utilizes the butylene stream for alkylation as well as making Butadiene. Also the furfural unit is operated to separate butadiene from a mixture of butane, butylenes, and butadiene.

Dehydrogenation Area. As shown in Figure 1, this area includes the equipment required for preheating and dehydrogenating the feed, for quenching and compressing the effluent reaction gas, and for regenerating the catalyst. The associated vapor recovery unit contains the equipment for the removal of byproduct light ends by means of an absorber-stripper cycle. Because of the large equipment sizes involved, and to provide operational flexibility, a good portion of this area is split into two identical parallel process trains (See Figure 1).

Fresh butane feed and recycle streams from storage are combined and vaporized by exchange with hot quench oil. This vaporized feed then passes through fired heaters where it is super-heated to the required reaction temperature.

The heated feed vapors flow through the reactors at 3.5 psia and is dehydrogenated. The reactor effluent gas is immediately quenched with oil in two stages of direct contact towers. The hot quench oil is used to vaporize the unit feed before being cooled and returned to the quench towers. The quench effluent gas flows to the product compressors.

Seven reactors which are horizontal, refractory lined vessels containing a bed of chrome oxide-alumina catalyst make up each reactor train. Coke, deposited on the catalyst during the reaction period is subsequently removed by combustion with air during a regeneration period. Prior to the introduction of air, the reactors are purged and evacuated.

After regeneration, the reactors are evacuated and purged to remove residual oxygen before re-introducing feed hydrocarbons. Three reactors are on stream, three are on regeneration, and one is on purge, evacuation, or valve change at any given instant. A master cycle timer, actuating hydraulically operated valves, controls the cycle for each reactor train.

The regeneration air is compressed by turbine-driven axial compressors and preheated to the desired temperature by direct combustion with fuel gas. The hot effluent flue gases from the reactors flow through waste heat boilers for steam generation prior to exhausting to the atmosphere.

For safety reasons, the hydraulically operated reactor valves are sealed with inert gas which is automatically cut in when the valves are in their closed position.

The reaction effluent gases contain butadiene, butylenes, unreacted butane, hydrogen, light hydrocarbons, small amounts of inert gas from the valve blanketing, and steam from reactor purging. Three stages of compression are used to compress the gases to 145 psig. Interstage cooling is provided and direct water injection into the first and second stage compressors is used to limit the gas temperature as a precaution against butadiene polymerization. Facilities are employed for the continuous injection of blade washing oil to the second and third compression stages.

The compressed vapors are then processed in a conventional absorber-stripper cycle employing naphtha as absorption oil. The absorber is designed to recover a portion of the propane and all of the butane, butenes, butadiene, and heavier components. The rich oil is sent to the stripper for removal and condensation of the mixed product stream, which is then pumped to run-down storage.

To prevent an undesirable build-up of impurities in the absorption oil, a continuous slip stream is fed to a small fractionating column for purification.

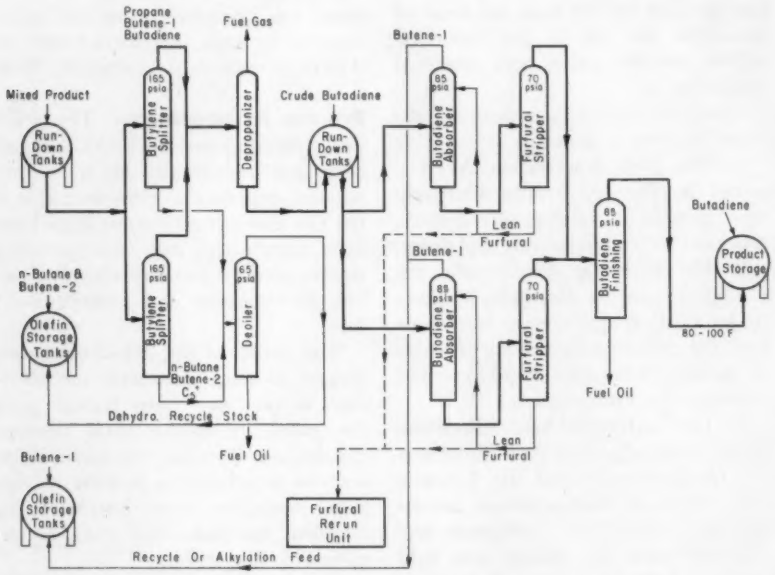

FIGURE 2—This schematic flow diagram of the butadiene recovery area shows the two parallel trains in this unit because of the large equipment sizes.

Butadiene Recovery Area. Figure 2 is a schematic diagram of the butadiene recovery area. Here the product butadiene, from the dehydrogenation area, is separated from the mixture of butane, butenes and residual light ends. The butylene splitter separates the butadiene and lighter components from the butane and heavier components.

The butylene splitter overhead is then depropanized and the crude butadiene and butene-1 are pumped to rundown tanks. The bottoms are deoiled in a fractionating column designed to remove any heavy ends, principally butadiene dimers. The butane and butene-2 are then pumped to storage for use as recycle to the dehydrogenation area.

The depropanized crude butadiene and butene-1 is separated by extractive distillation using furfural as a selective solvent for butadiene. The butadiene absorber overhead stream of butene-1 is sent to storage for use as either recycle to the dehydrogenation area or as feed to the alkylation area.

The butadiene is recovered by stripping from the furfural and then removing any residual impurities, principally small amounts of heavy acetylenes and butene-2, in a final finishing fractionation column.

As shown in Figure 2, portions of the butadiene recovery area are split into parallel trains, because of equipment size. This not only provides operating flexibility but, combined with the parallel dehydrogenation reactor trains, allows scheduling of staggered shut-down for catalyst change-overs.

To prevent an undesirable build-up of butadiene and furfural polymers, a small rerun unit is provided for purification of a slip stream of furfural either continuously or on a batch basis.

Provisions are also made for continuous injection of an aqueous nitrite solution into the major fractionation columns as a precaution against a build-up of peroxides and the resultant accelerated formation of butadiene polymers, to avoid reboiler fouling problems.

Alkylation Area. The alkylation area (Figure 3) contains all of the equipment necessary to react the butane-butene streams from the recovery area with fresh *iso*-butane feed and to separate the reaction products into an internal *iso*-butane recycle stream, normal butane for recycle to the dehydrogenation area, a light alkylate product, and a motor alkylate product.

The area is a conventional effluent refrigeration sulfuric acid alkylation plant. It includes four parallel contactors designed for operation of all or part of the contactors. One design innovation was the combining of the usual compressor dry drum with the refrigerant flash drum into a single vessel resulting in a significant capital cost savings as well as in simplifying the unit operation. Another innovation employs the liquid refrigerant stream to cool the flow of compressor anti-surge gas by direct contact and heat transfer, resulting in a system which can be "blocked in" and put on recycle for indefinite periods.

A conventional fractionation train of four columns (Figure 3) splits the reaction effluent into an internal *iso*-butane recycle, *n*-butane for recycle back to the dehydrogenation area, and into the two product alkylate streams. The 335 F. end point light

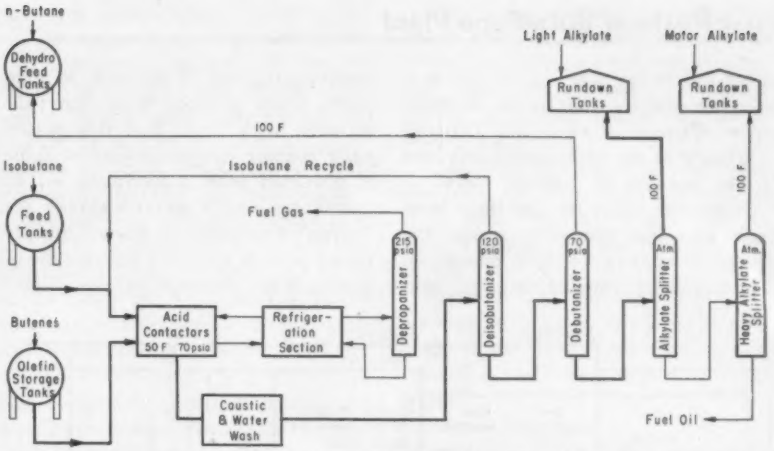

FIGURE 3—Schematic flow diagram of the alkylation area. This area is actually composed of four parallel reactors which give unusual operational flexibility.

alkylate is blended with *iso*-pentane (or other suitable blend stock) leaded with TEL, and marketed as 115/145 aviation gasoline. The 400 F. end point heavy alkylate is marketed as a motor gasoline blending component.

Cycle Timer. The "brain" of each dehydrogenation reactor train is the master cycle timer. The timer controls the cyclic process and safeguards the unit against mal-operation. The timer sends the electrical impulses to initiate opening and closing of reactor valves, and also checks in subsequent steps on whether or not the valves have actually moved to their correct and safe position. The timer also checks the pressure in the reactor to determine if it is safe to proceed to the next phase. Should a timer check fail to be satisfied, the timer automatically stops and sounds an alarm. At the same time, an electrical brake is applied to keep the timer from "coasting" to the next point.

The timer goes through 900 points in a 21 minute cycle (however, all of the points are not actually used). During this 21-minute cycle, each of the seven reactors is on stream 9 minutes, on regeneration 9 minutes, on various purge and evacuation steps for 1½ minutes, and switching valves for 1½ minutes.

Through an electrical circuit which is completely independent of the cycle timer test circuits, a system of electrical interlocks prevents the opening of any individual valve unless the

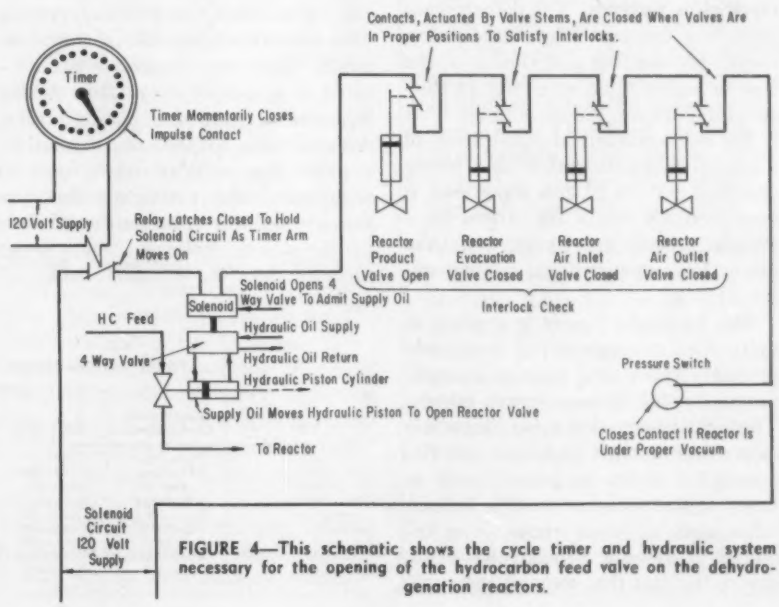
Contacts, Actuated By Valve Stems, Are Closed When Valves Are In Proper Positions To Satisfy Interlocks.
Timer
Timer Momentarily Closes Impulse Contact
120 Volt Supply
Relay Latches Closed To Hold Solenoid Circuit As Timer Arm Moves On
Reactor Product Valve Open
Reactor Evacuation Valve Closed
Reactor Air Inlet Valve Closed
Reactor Air Outlet Valve Closed
Interlock Check
Solenoid
Solenoid Opens 4 Way Valve To Admit Supply Oil
HC Feed
Hydraulic Oil Supply
4 Way Valve
Hydraulic Oil Return
Hydraulic Piston Cylinder
Pressure Switch
Supply Oil Moves Hydraulic Piston To Open Reactor Valve
To Reactor
Closes Contact If Reactor Is Under Proper Vacuum
Solenoid Circuit 120 Volt Supply

FIGURE 4—This schematic shows the cycle timer and hydraulic system necessary for the opening of the hydrocarbon feed valve on the dehydrogenation reactors.

other valves on that reactor are in a safe position for that phase of operation. Figure 4 shows a typical schematic of the components involved in the opening of a single valve.

Numerous other devices have been built into this system to insure the complete safety of this operation. These safety devices, alarms, and motions require 21 seconds to complete, there is more than one valve moving at a time. For this reason, each reactor hydraulic control panel is provided with a hydraulic oil accumulator which accumulates and "stores" hydraulic oil during low demand periods and then releases the oil during high demand periods. Figure

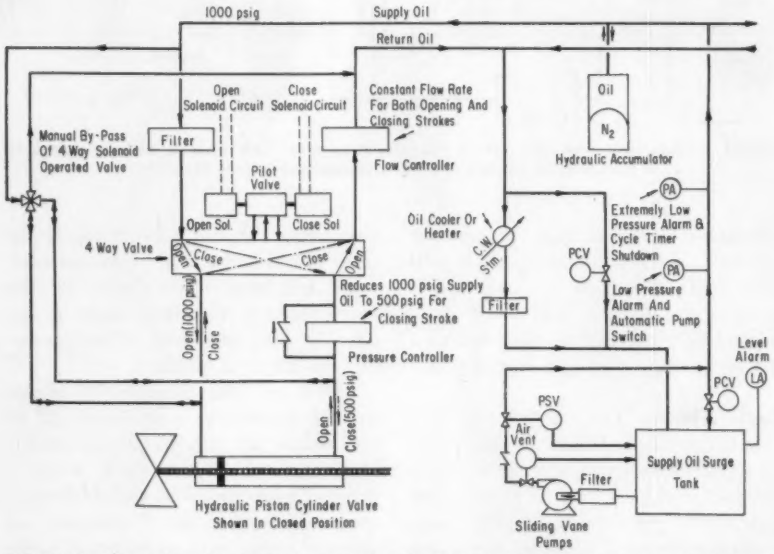

FIGURE 5—This schematic shows the control and safety devices incorporated in the hydraulic system for one valve on the dehydrogenation unit.

lights, indicating the open or closed position of each of the 50 valves per reactor train, are all located in the dehydrogenation unit control room.

Hydraulic System. The dehydrogenation unit employs a hydraulic power system for opening and closing of the reactor valves upon receiving an electrical signal from the cycle timer. This is the first commercial application of a central hydraulic system in a petrochemical process of this scope and is very probably one of the largest commercial applications of hydraulic power for an operational control system.

The hydraulic power is applied to each valve as a product of flow times pressure. The system pressure is maintained by sliding vane rotary pumps. The dehydrogenation cycle inherently causes intermittent high and low demands for hydraulic power since, at times, it is required to move a 30-inch valve and, at other times, it is required to move a 3-inch valve. Also, due to the fact that some of the valve 5 is a typical schematic of the hydraulic system components.

In order to control the rate of opening or closing of each valve in the time allotted for that valve motion on the cycle timer, each valve control unit contains a hydraulic oil flow controller. The flow controller is so located as to control the oil flow during both the opening and closing stroke. Also, in order to prevent "slamming" a valve shut with enough force to wedge the valve too tightly closed, a pressure reducer controls the oil flow for the closing stroke at a much lower pressure than the opening stroke oil flow.

A 4-way solenoid operated valve directs the oil flow in the proper direction for the desired opening or closing stroke (Figure 5). The 4-way valve has both an "open" solenoid and a "close" solenoid which receive their signal from the cycle timer as depicted in Figure 4.

In the event of a failure of the solenoid operated valve to function properly, a manual 4-way bypass is provided.

Not shown in Figure 5, but included within the hydraulic piston cylinder, is a "hydraulic cushion" which causes the reactor valve to travel at a very slow rate during the last fraction of the opening and closing strokes as an additional precaution against "slamming" a valve.

Compressors. The process equipment includes five relatively large compression systems and has probably some of the largest axial flow compressor installations in any petrochemical process unit. The two regeneration air blowers are 9700 bhp axial air compressors operating at 3600 rpm. These machines contain five stages of blading and are driven by condensing steam turbines.

The two first stage reactor effluent gas compressors are 3800 bhp axial compressors operating at 3600 rpm. These machines contain 11 stages of blading and are also driven by condensing steam turbines.

The two second-stage and the two third-stage gas compressors are conventional centrifugal units also driven by condensing steam turbines.

The alkylation area refrigeration compressor is a 4275 bhp centrifugal compressor driven by a back-pressure steam turbine. The 70 psig exhaust steam derived from this unit is sufficient to supply all of the 70 psig reboil heat requirements of the alkylation area.

On-Stream Analyzers. The TB & C plant was designed for maximum

TABLE 1—On-Stream Hydrocarbon Analyzers

TYPE	Monitored Component	Function	Location
Ultra-violet	Butadiene	Controller	11th tray north butylene splitter
Ultra-violet	Butadiene	Controller	11th tray south butylene splitter
Ultra-violet	Butadiene	Recorder	Deolier overhead & depropanizer overhead
Ultra-violet	Butadiene	Recorder	North and south butadiene absorber overhead
Ultra-violet	Butadiene	Controller	5th tray butadiene finishing column
Infra-red	Butene-1	Controller	25th tray north butadiene absorber
Infra-red	Butene-1	Controller	25th tray south butadiene absorber
Infra-red	Acetylenes	Controller	79th tray butadiene finishing column
Chromatog	Butane	Recorder	89th tray south butylene splitter

utilization of on-stream hydrocarbon analyzers. Even within the short period of experience thus far gained with these instruments they have proven themselves to be invaluable. Table 1 is a tabulation of the nine analyzers and their functions.

Plant Start-Up. Texas Butadiene & Chemical Corporation assumed the basic responsibility for the initial start-up. The contractor and the three licensors furnished technical and operating advisors during the first few weeks of initial operation.

The entire plant start-up was characterized by relatively smooth operation and very few process problems were encountered. The high caliber of TB&C operating personnel and an excellent pre-start-up training program contributed greatly to the smooth start-up.

The pre-start-up training program was divided into classroom study, written examinations, field study in the unit areas, and verbal field examinations. As an incentive to promote interest in the training program, the classification of each operator was decided upon completion of the training program and was determined entirely by his performance during the training program.

The program was organized and supervised by TB&C operating supervisors, assisted by TB&C engineers. The contractor's personnel, licensors' advisors, and equipment vendors' representatives were also utilized.

To facilitate the initial operation and in order to get on stream more rapidly, the processing areas were turned over to TB&C by "pieces" as they were completed. The initial unit turned over to TB&C was a portion of the utility area on December 12, 1956. By mid-December, part of the steam generation facilities were on stream.

The first dehydrogenation unit was turned over on Jan. 5, 1957. Within 46 days, on February 21, the unit was on stream. During this period, the reactor brickwork and all of the fired heaters were dried out and catalyst was loaded. Upon completion of the dry-out and catalyst loading, the reactors were heated up with hot regeneration air. The remainder of the unit was air-freed with inert gas and the product compressors were started on a recycle operation. As soon as a vacuum test was completed, the inert gas was displaced with a butane-fuel gas mixture. At this point, the automatic cycling of reactor valves was initiated and, shortly afterwards, butane was charged to one reactor on a once-through basis. As soon as all seven reactors were commissioned, the unit was on-stream.

The recovery area was turned over to TB&C on February 1. Since it was desirable that the recovery unit be on stream prior to the dehydrogenation unit, an outside feedstock was purchased for the start-up. By February 21, the recovery area was on stream and completely ready to receive the dehydrogenation effluent as the first unit went on stream.

The alkylation area was turned over on February 1 and, by February 21, it was partially on stream, charging one contactor section. On February 26, all four contactors were on stream.

All indications to date are that the plant will meet the design expectations as to yields, product purities, and product recoveries.

Plant Utilities. The plant steam requirements are furnished by four 600 psig steam generating units rated for a total of approximately 1 million pounds per hour. About 240,000 pounds per hour of 250 psig steam is derived from the dehydrogenation unit waste heat boilers.

Cooling water is supplied by an eleven-cell induced draft cooling tower rated for 116,000 gallons per minute at an overall ΔT of 23 F.

About 25 percent of the plant fuel gas requirements are supplied by off-gas streams from the processing units. The remainder is purchased from outside sources.

Other utilities include instrument air, fire and potable water, water treating facilities, normal and emergency electrical power, and inert gas generation units.

Offsite Facilities. The Lyondell Plant is an integrated and self-sufficient plant complete with all the required on and offsite facilities.

The plant site storage includes 139,000 barrels of LPG storage spheres for butane, *iso*-butane, butenes, crude butadiene, and product butadiene. The avgas rundown, blending, and product storage includes 10,000 barrels of spheroid tankage; 60,000 barrels of floating roof tankage, and 20,000 barrels of cone-roof tankage.

The offsite storage is located at Mont Belvieu, Texas, where the TB&C engineering staff designed and had constructed some 1.5 million barrels of underground salt dome storage for LPG.

Pipe lines to and from the plant site total to some 63 miles and include lines to Mont Belvieu and the Hess Terminal on the Houston ship channel.

Railroad tank car loading and unloading facilities at the plant site include 12 car spots. Truck loading and unloading facilities include 4 truck spots.

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About the Authors

Brack

W. J. BRACK is area superintendent in charge of dehydrogenation area operations at Texas Butadiene and Chemical Corporation's plant at Channelview, Texas. Brack graduated from the University of Texas with a B.S. degree in chemical engineering in 1952. Following graduation he joined Olin Mathieson Chemical Corporation at its Doe Run plant in Brandenburg, Ky., where he worked on various phases of design and production until 1956.

M. R. BEYCHOK is a process engineer with The Fluor Corporation, Ltd., Los Angeles. He graduated from Texas A & M College in 1947 with a B.S. degree in chemical engineering, then went to work for Shell Oil Company at its Deer Park, Texas, refinery as a research chemist. He later joined Rothschild Oil Company, Santa Fe Springs, Calif., as chief chemist prior to joining Fluor in 1952.

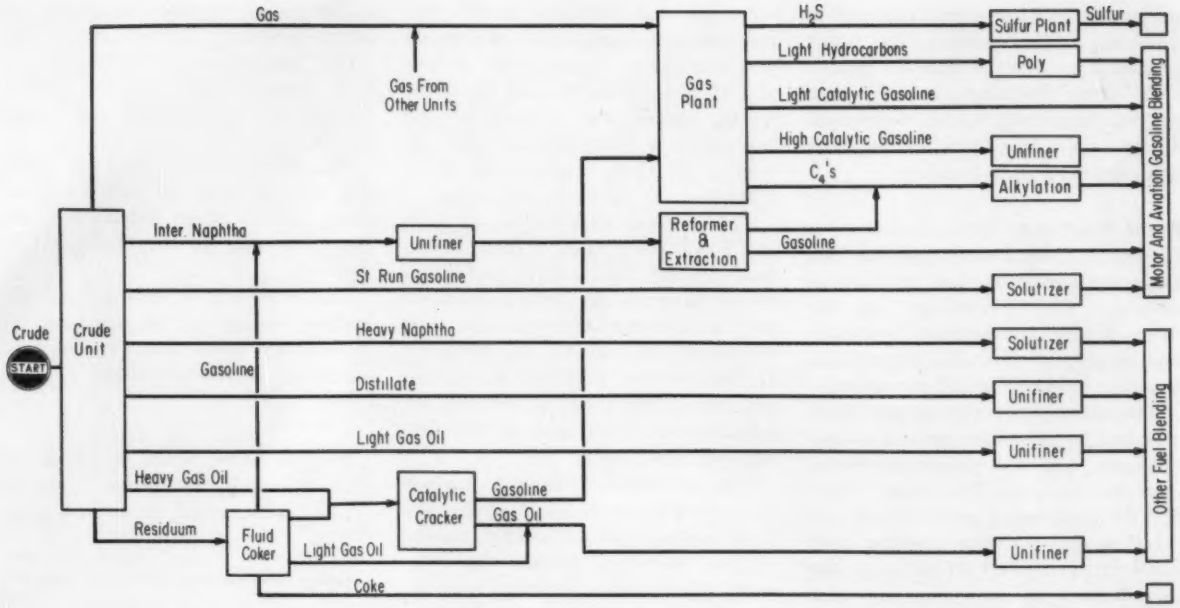


FIGURE 1—Flow scheme for new Tidewater refinery. Units are more interdependent than in a conventional refinery.

How Tidewater Built Newest Refinery

130,000-bpd Delaware plant has largest initial capacity of any refinery yet built.

TIDEWATER OIL COMPANY's $200 million, 130,000 barrels per day Delaware refinery was dedicated May 23. The new plant, the largest refinery ever built from scratch, includes six of the world's biggest units and incorporates many unique concepts, economic as well as strictly technological in nature. The Delaware refinery is highly automated and units are more interdependent than in any other refinery, as large, single units characterize each refining step instead of two or more similar ones present in more conventional plants. The number of employes (500, when construction is completed) is small compared to the throughput capacity of the refinery. Maintenance is being contracted to an outside firm.

The crude unit, fluid catalytic cracker, fluid coker, cat reformer, solvent extraction plant, and hydrodesulfurization units represent the largest of their respective types in the world. However, Tidewater has, in addition, a fluid coking unit under construction at the Avon refinery at Associated, Calif., which will equal the capacity of the coker at Delaware (42,000 barrels per day vacuum residuum, or 1200 tons of coke per day output).

In building the huge Delaware refinery, Tidewater has, at least temporarily, reversed the postwar trend toward the construction of relatively small, specialized refineries, later expanded as economic conditions warrant. In this instance, the company has found it more expedient in the long run to discontinue smaller, obsolescent, less economical older plants and build an entirely new, ultramodern, highly controlled refinery geared to production of modern, high quality products.

In making the new plant more interdependent unit for unit, Tidewater is relying more heavily on modern instrumentation and methods of control than has been the practice heretofore.

At the start, Tidewater bought 5000 acres adjoining the Delaware River, near Delaware City, reportedly the largest tract of land ever purchased for industrial purposes on the eastern seaboard. Since then, 3500 acres have been leased to Seabrook Farms, to assure maintenance of attractive adjoining territory. The main process area, covering 480 acres, is located one and a half miles inland from the river. Construction began late in 1955, rounding into full swing in early 1956 and continuing through the present time.

What sets the refinery in a class by itself is the size of the various units—six are the biggest in the world (see copy at right). Tidewater has no immediate plans for expansion but it is expected that petrochemicals will eventually be produced.

The crude distillation unit, designed by C F Braun and Co, is running 130,000 barrels of crude per day. This unit is designed to run a variety of types or blends of crude oil, primarily medium-gravity, high-sulfur content crudes.

The Orthoflow fluid catalytic cracker, about 250 feet high, charges 58,000 barrels daily of straight-run gas oils from the crude unit and 44,000 barrels daily of recycle stock. The regenerator section is 59 feet in diameter, placed above the reactor section. With the exception of size, the cat cracker is of conventional design and operation. The feed is converted to high-octane gasoline, gas oils, butanes, propanes, dry gas and coke.

The fluid coking unit charges vacuum residuum from the crude unit. The resid is upgraded into gas, gasoline, gas oil, and coke. The unit charges 42,000 barrels of residuum daily and produces 1200 tons of coke. Most of the coke is used as fuel in the Delaware Power and Light Company's 50,000 kilowatt plant which provides electricity for the refinery. The remainder of the coke is sold elsewhere.

Next in line is the gas plant, which receives gas from most of the other units and gasoline from the cat cracker. The cat gasoline is used as an absorbing medium. After gas recovery the cat gasoline is split into two streams, a light and a heavy stock.

The catalytic reformer charges 45,000 barrels of naphthas from the crude unit daily, upgrading the charge into high-octane automotive and aviation gasoline stocks. Hydrogen for the hydrodesulfurization plant is also produced.

Why Small Force. The total number of employes for the refinery is only 500, since Tidewater has less than 20 on the maintenance force. But even counting contract maintenance, the force totals only about 750 men. This contrasts with 1600 employes, who ran the old Bayonne Tidewater refinery (capacity, 88,000 bpd). Modern equipment, especially instrumentation, explains in large part the efficient use of manpower at the refinery.

Tidewater has a small management force to direct the maintenance operation, consisting of a manager and an area coordinator for each of three plant areas. An instrument engineer, an electrical engineer and a corrosion inspector support the area coordinators. The rest of the maintenance staff is the responsibility of the maintenance contractor, who plans, estimates, schedules and supervises the field work.

Tidewater also has a small force of general service operators on a three-shift basis to assist unit operators in various problems including: miscellaneous emergency and routine service, dockside services for tankers and barges, and miscellaneous duties such as fire-fighting.

One Unit for Each Step. Tidewater has a position unique to most refineries of this size. Each processing step, with the exception of treating, has only one unit for achieving the operation. Furthermore, the minimizing of intermediate storage makes each unit more closely dependent on the operation of the other. They will achieve this close-knit operation through rigid control by applying elaborate instrumentation and by averting unscheduled shutdowns with preventive maintenance.

High Degree of Treating. The capacity for hydrogen treating is about 70 per cent of crude running capacity. This is almost twice the proportion used by most refineries. Hydrogen use is so extensive that the catalytic reformer will not be able to supply all the hydrogen needed. To obtain the additional hydrogen, Tidewater cracks propane in a hydrogen plant.

Power from Coke . . . For detailed analysis of how Tidewater gets its power, see "Refinery Trades Coke for Power," Petroleum Refiner, August, 1956, Page 141.

The Eleven Units in Brief

CRUDE
Designed: C F Braun & Company
Capacity: 130,000 bpd crude oil
Type: Two-stage—atmospheric and vacuum

*FLUID CATALYTIC CRACKING UNIT
Design: Kellogg
Capacity: 102,000 bpd (58,000 bpd Virgin Gas Oil—44,000 bpd recycle stock)
Type: Orthoflow

*COKING UNIT
Design: Esso R & E
Capacity: 42,000 bpd Vacuum Residuum (1200 tons coke per day)
Type: Fluid

GAS PLANT
Design: C F Braun & Company
Capacity: 88 million cubic feet daily
Type: Absorption

*REFORMER UNIT
Design: Houdry
Capacity: 45,000 bpd intermediate naphtha
Type: Houdriformer

POLYMERIZATION UNIT
Design: Universal Oil Products Company
Capacity: Produces 5800 bpd poly gasoline
Type: Chamber

ALKYLATION UNIT
Design: The M. W. Kellogg Company
Capacity: Produces 5000 bpd alky gasoline
Type: Sulfuric Acid

SOLVENT EXTRACTION UNIT
Design: Universal Oil Products Company
Capacity: 40,300 bpd
Type: Udex

*HYDRODESULFURIZATION UNITS
Design: Universal Oil Products Company
Capacity: Five units for a total of 88,000 bpd
Type: Unifining

HYDROGEN PLANT
Design: Girdler
Capacity: 30 million cubic feet of hydrogen
Type: Propane Reforming

SULFUR PLANT
Design: Ralph M. Parsons Company
Capacity: 340 tons per day
Type: H_2S Combustion

* Largest units of their type in the world.

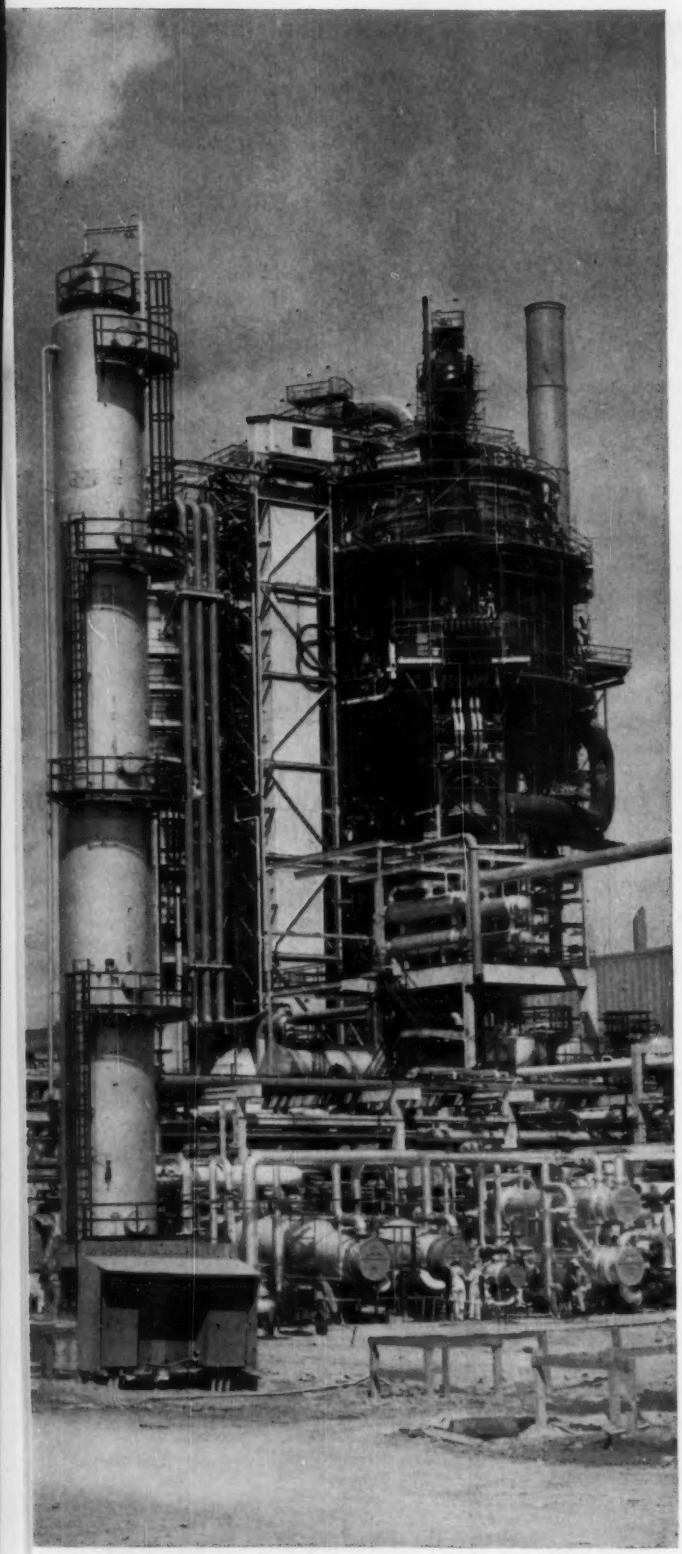


FIGURE 1—The main fractionator of the 102,000-bpd fluid catalytic cracking unit is 120 feet high and 25 feet in diameter. The bottom 64 feet of the vessel is fabricated of 12 percent chromium stainless clad steel in gages ranging from 5/8 to 11/16 inch. The slurry settler immediately behind the main fractionator is 30 feet high and 17 feet 6 inches in diameter. It is clad with 12 percent chromium stainless steel, 19/32 inches in gage.

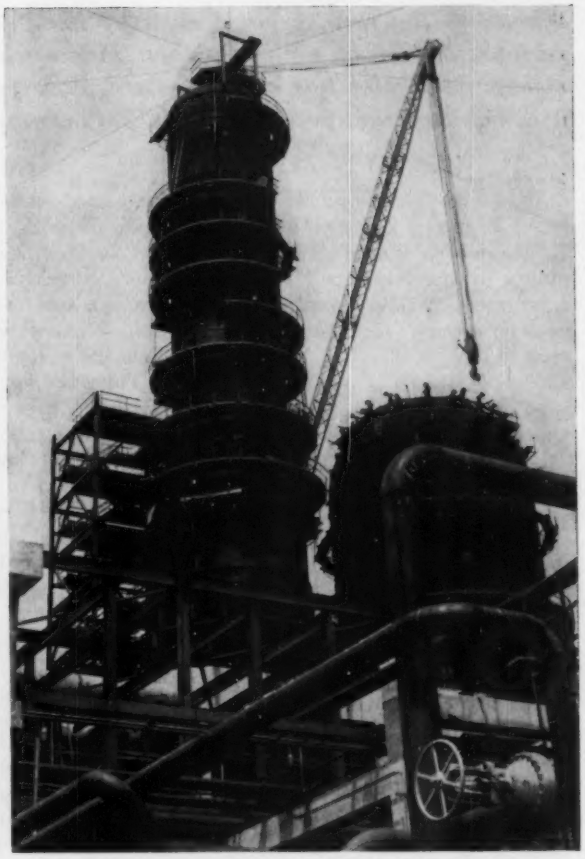


FIGURE 2—Shown under construction is the fluid coker reactor scrubber (left) and the coker fractionator tower. The reactor scrubber is 90 feet high and 23 feet 6 inches in diameter. The scrubber is the top section of a double vessel some 200 feet high. 316L stainless clad steel in gages varying from ½ to 1¼ inches was used in the reactor scrubber. The fractionator tower is 91 feet high with a diameter of 21 feet. Monel clad steel is used in the upper portion and 12 percent chromium stainless clad in the lower, in gages varying from 7/16 to 9/16 inches.

New Tidewater Refinery

Where and Why

Joseph H. Proctor, Manager of Marketing Service, and **Albert Hoersch,** Technical Service Engineer
Lukens Steel Company
Coatsville, Pennsylvania

ALLOY AND ALLOY-CLAD steels form the very backbone of any modern refinery. This is especially true in Tidewater's new 130,000 barrel-per-day Delaware refinery. Many thousands of tons of steels of all types were used in building this newest and most modern refinery.

More than 2000 tons of specialty steels—two types of alloy and nine types of clad steel—were specified as the most efficient and economical answers to certain corrosion, heat, and pressure problems which occur at the very heart of a modern refinery.

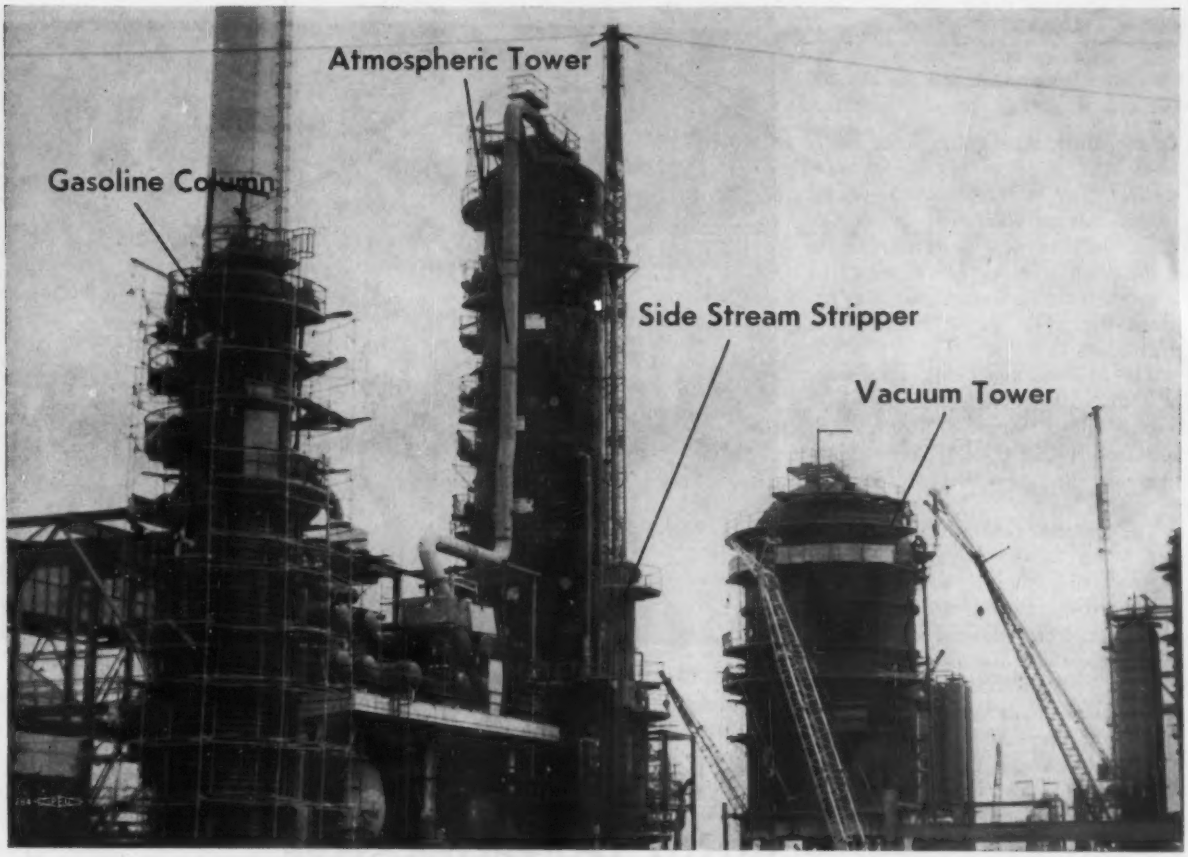


FIGURE 3—The crude unit above is shown under construction. The gasoline column (96 feet high by 12 feet 6 inch in diameter) has the upper portion monel clad in gages from ⅜ to ⅝ inches. The atmospheric tower (151 feet high with diameters from 19 feet to 23 feet) has the lower 58 feet 316L stainless clad and the upper section monel clad. The three compartment side stream stripper has the bottom compartment clad with 316L stainless. The vacuum tower stands 150 feet high and varies in diameter from 13 feet at the bottom to 40 feet at the top. The bottom 71 feet is fabricated of 316L stainless clad in gages varying from ⅝ to 1⅛ inches. The gasoline stabilizer (not visible in this photograph) is 68 feet high and varies in diameter from 7 feet 6 inches at the bottom to 5 feet 6 inches at the top. The lower section is clad with an alloy of 78 percent nickel-15 percent chromium-6 percent iron and upper section clad with 15/16 inch gage monel.

Alloys Were Used

The two alloys were types A204 (a carbon-molybdenum alloy) and A301 (a chromium-molybdenum alloy). Clad steels were types 304, 304L, 316, 316L, 405, 410, Monel, and a 78 percent nickel-15 percent chromium-6 percent iron alloy.

These steels were specified for literally hundreds of small vessels and heat exchangers for seven of the major processing units of the refinery.

Fluid Coker. The *reactor scrubber* used 316L stainless clad steels in gages varying from ½ to 1¼ inch to resist corrosion from sulfur compounds and naphthenic acids.

The *fractionator tower* used monel clad on upper section and 12 percent chromium stainless clad in lower section gages varying from 7/16 to 9/16 inch primarily to resist

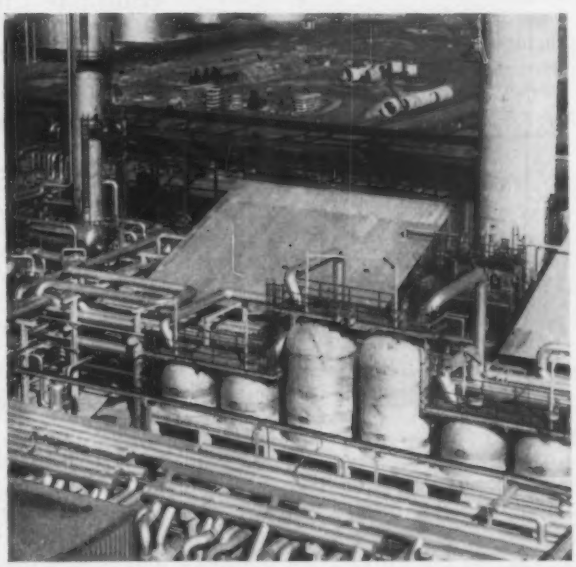


FIGURE 4—This over-all view of the catalytic reformers shows the reactors. They were constructed of A301 Grade B alloy steel because of its superior strength characteristics at high operating temperatures and pressures. This steel, a chromium-molybdenum alloy, was specified in gages from 2½ to 5 inches.

corrosion from mineral acids and sulfur attack.

Crude Unit. The *atmospheric tower* used 316L stainless clad in the lower section to resist corrosion from sulfur compounds and naphthenic acids. The upper section was constructed of monel clad steel to resist corrosion from such strong mineral acids as hydrochloric. The gages varied from 9/16 to 5/8 inch.

The *vacuum tower* was constructed of 316L stainless clad in the lower 71 feet to resist corrosion from sulfur compounds and possibly from naphthenic acids. Gages used varied from 5/8 to 1 1/8 inch.

The *gasoline column* used monel clad steels in the upper portion in gages varying from 3/8 to 5/8 inches to resist corrosion from hydrochloric acid and other strong mineral acids.

The *gasoline stabilizer* was constructed of steel clad with an alloy of 78 percent nickel, 15 percent chromium and 6 percent iron in the lower section and monel clad steel in the upper section. Gages of 15/16 inch were used to resist the classic corrosive compounds found in straight-run gasoline.

The *side stream stripper* is a three compartment vessel. The bottom section (the high temperature section) was constructed of 316L stainless clad material. In order to resist corrosion from sulfur compounds and naphthenic acids even the head separating the lower section from the next upper section was clad on the convex side.

Fluid Catalytic Cracker. The *main fractionator* had the bottom 64 feet fabricated of 12 percent chromium stainless clad steel. To meet the corrosion problems posed by sulfur compounds gages ranging from 5/8 to 11/16 inches were used.

The *slurry settler* was fabricated from 12 percent chromium stainless steel clad in 19/32 inch gage to resist abrasion from the catalyst and corrosion from sulfur compounds.

Catalytic Reformer. The *reformer reactors* were constructed of A301 Grade B alloy steel. This steel, a chromium-molybdenum alloy, was specified in gages from 2 1/2 to 5 inches because of its superior strength characteristics at high operating temperatures and pressures (approximately 950 F and 536 psi). # #

CAT CRACKER SUITE—Human scanners can't compete with this mechanical system.

Where Tidewater Used New Instruments

Data logging and scanning combined to form complete information systems at each unit.

James McDonald
Tidewater Oil Company, Delaware City, Del.

WHEN TIDEWATER started its design of the new Delaware refinery, the instrument industry was able to say, "you name what you want to do and we will do it!" Here is what Tidewater considered and what they chose to make their "refinery of the future."

Pneumatic Choke. Prior to the decision to install information systems, it has been decided to use pneumatic instrumentation. This decision in 1955 sprang from two facts. Electric signals and electronic controllers and indicators had not reached the stage of standardization. The electric valve was still in the future. We did not feel that this type of instrumentation had any special advantages over the pneumatic. Rather, it appeared to offer the same degree of control by using different principles. Since we knew that pneumatic to electric transducers were readily available for the proposed information systems, we preferred to proceed with "conventional" pneumatic instrumentation.

At the outset we were much less interested in logging than in scanning. In fact, it is seriously doubted that we would have adopted logging alone, if scanning had not been available. Data logging alone has rather obvious limitations. It will present a true and accurate picture once an hour, or on demand, and as such fulfills a definite need. But as we all know, a process unit can get into all kinds of trouble in far less than an

hour. What we were looking for was continuous scanning so that our operators could "nip trouble in the bud." A scanner which would not only announce an off-normal point but would also give it a digital value seemed almost too good to be true.

Such a device tied on to the automatic logger and using much of the same equipment for the dual purpose seemed to really complete the picture. Then combine this with the ability of the operator to plug in any variable on a patch board and get a digital indication. And then add in placing the operator at the focal point of a wrap-around panel complete with good visibility miniature recorders and controllers, plus readily available trend recorders. All of this adds up to an information center for the operator. If anything which is measureable goes wrong the operator should catch it quickly. In many cases, quick action can avoid further upset. The unit can be pushed closer to maximum efficiency and ultimate capacity from many points of view.

Crude Unit Example. Let us consider the problems of operating a large crude unit like the Delaware 130,000 bsd unit. Such a unit has heaters, towers, strippers, exchangers, coolers, pumps, a compressor, desalters, piping and many auxiliaries. After placing the unit on the line the age-old problem of maintaining uniform operation at maximum efficiency sets in. In general, in a modern unit, the main items which trouble the operators are the movers and the heaters. Pumps and compressors have to be watched. In spite of the advances in the art of building machinery, there are always some troubles such as packing seals, vibration, etc. A well designed heater will respond beautifully to automatic control, but still has to be watched for hot tubes, flame impingement, etc. But beyond these points, the ability of the unit to do a top-notch job lies in hands of the instrumentation.

The day of the automatic crude unit is approaching. Our cousins on the pipe lines have come up with the automatic pumps station. If our pumps, compressors and heaters were infallible we, too, could take a crack at it right now. We would then come up against the next big IF. The unit would operate perfectly IF the instrumentation were perfect. In practice this doesn't happen and it is necessary to constantly monitor the operation of the control instruments. Then, too, there are many places it probably doesn't pay to install automatic equipment. An example of this lies in the control of the cooling water through a product cooler. It is a second order control problem since both the temperature of the cooling water outlet and the product temperature must be watched and the critical one allowed to control the flow of water. This is easily done by an operator provided he has the information available. Too often he doesn't have the information at his fingertips so water is wasted.

So right now our hypothetical crude unit needs a crew to monitor its operation. They perform certain definite jobs like controlling cooling water, changing pumps, watching heater tubes and burners, etc. The rest of their job really makes them human scanners. They look at any piece of information which helps them run an efficient, continuous operation on the unit. Their scanning includes watching all kinds of temperature, flows, pressures, levels, etc. It also includes scanning physical equipment like pumps, compressors, etc., for signs of mal-operation.

Automatic Scanner. Into this concept we now introduce the automatic scanner. This device can take over the scanning of the temperatures, flows, pressures, levels and the like and do an excellent job. The degree of the excellence can be set by the fineness of the scanner settings. Human scanners are wont to brag about how well they can scan the variables in an operating unit. How can they compete with a scanner running at the rate of five variables per second? Once the concept of the scanner is adopted, then many possibilities for maximum utilization present themselves.

Many refiners complain that it is not possible to bring in readings of too many variables to the board since they would wind up with a board literally too large for comprehension (and human scanning). Using a mechanical scanner, it is possible to pipe in all kinds of readings which can then be on tap for the scanner, the digital indicator or trend recorder if desired. The expense is not too great since separate board-mounted indicators are not required for all variables. The scanner can keep an eye on all of these points for the operator.

The next point which was considered was how big do we make the scanner? With scanning speeds being what they are, one big one could scan the whole refinery. Then one man would try to wind up calling the shots for the whole refinery. This seemed most impractical. Since we planned large single units, it seemed ideal to place a scanner in each unit. This then places one man at each unit in the position of having literally all there is to know about one unit presented to him. It was believed that this was within their scope of comprehension.

There was one last item which was most desirable, but heretofore not readily available in printed form. Integrated figures on shift and daily rates of flow, averaged daily figures on temperatures, pressures, flows, etc. plus other averaged data are most useful to give management at all levels a condensed picture of the operation. When such figures are entered in tabular form, it is possible to detect trends and variances in operating conditions. Obviously, the Accounting department could use the integrated flows to determine charges and yields.

Information Scope. The design of the instrumentation and information systems took all of the above into account and more. The installation contains thirteen complete information systems. It includes 12 scanners, 18 typewriters, 18 digital indicators, 10 consoles and 15 trend recorders all installed in nine control rooms.

Below is a summary of other items included in the information systems:

Total point capacity of systems	4590
Points Logged	1935
Points Blind-Scanned	995
Points Integrated or Averaged and logged for accounting	786
Transducers	833
Integrators	208
Flow points	321
Pressure points	261
Temperature points	791
Points on patch panels	2240

In each case, the console containing the digital indicators, the typewriters and auxiliary alarms and backed up by the trend recorder, is placed at the focal point of the control room. This enables the head operator to visually scan his board. A failure of the scanner and/or logger does not put him out of business by a long shot. All the controls and indicators keep running on the board.

The digital indicator is separate and also remains available. So the operation can continue without logging and scanning. Their many advantages may be lost to the operator temporarily, but the unit can continue to run (in the old-fashioned manner—as enhanced by the digital indicator).

Log sheets were made up for units in advance. These sheets contain complete headings and are made up like conventional log sheets except they are spaced for typing. A generous section is allowed at the bottom for off-normal print-outs. The log sheets are held up back of the typewriters by large metal back-up shelves so they can be kept in position for easy reading.

Each unit except the tank farm, has a patch board into which each variable is wired. Convenient plug jacks can then be used to show the variable on digital indicators or tend recorders. The indicators are mounted on the console in front of the operator, while the trend recorders are placed in a cubicle behind him. Also placed on the console are the emergency alarms in conventional lighted window boxes. These are all wired in separately. When they are initiated they are scanned and logged but do not depend on the scanner and logger to alarm.

Tape-Puncher. Each system contains a standard language tape-puncher. Any item which can be logged can also be placed on the punched tape. In practice, it was planned to punch out only the "accounting" data. This information includes averaged and integrated variables to be used by the Accounting department to calculate yields, costs and post operating data.

Another feature of the systems is a push-button for an off-normal read-out. The off-normal points are printed in red as they occur. When they return to normal, there is a print-out in black to show this return to normal. The off-normal print-out gives an incoming operator a chance to quickly find out which points are currently off-normal.

The tank farm information system is also unique. Making use of remote gaging and temperature indication, it is possible to pick up all tank levels and temperatures in the control room. These are shown on digital indicators, one in feet and hundreds and one in degrees. In addition, a logger and computer is utilized. It will soon be possible to print out the following at any time in seven minutes. For each of 88 tanks, tank number (pre-set), stock (pre-set), API Gravity group (pre-set), temperature and barrels corrected to 60 F. The latter is accomplished by means of a computer and data stored on a magnetic tape. The data on the tape are the actual "strapping" tables for each tank. The value of having this kind of data available is obvious.

In Operation. Now comes the big question. *How is it all working out?* Actually it is too early to give a comprehensive evaluation. The first complete unit was delivered in December 1956. Following installation and shakedown, this first unit, in the crude unit, is now ready to be fully utilized. The use of the equipment has been growing as the installation proceeded. The crude unit started in September 1956 and used the digital indicators and trend recorders from the start. Logging started in December 1956 and scanning has gained daily. The accounting data has reached the stage of being placed on the punched tape. The accounting people are getting lined up to use the tape and convert to the forms they want.

Many other loggers and scanners are being installed and are undergoing the same schedule as the one given for the crude unit. The timetable has been speeded up largely through experience gained at the crude unit. It now appears that all units should be fairly well installed and debugged by July 1957. By this time next year, a more complete evaluation will be possible.

In the meantime, we can report on what has been seen to date. In general, the systems work; in fact, they work well. There are no fundamental problems which cannot be licked. As in any new development there have been bugs of one kind or another. At this time, the debugging appears to have been successful and we are entering the phase of ever increasing service factor and dependability.

Our really big problem in connection with the information systems at this time lies in getting the operators to utilize them to the fullest extent. Having started the units without scanning and logging and witnessed the growing pains right in the control room, the operators as a whole tend to cast a suspicious eye at the new-fangled invention. We plan to launch an intensive training program at this critical and opportune time.

These systems are not readily accepted by experienced operators. They tend to feel that they can scan the unit themselves better than the scanner. This is probably understandable at this point since they lack faith in something they do not fully understand. There is a tendency to condemn the whole system if just one reading seems wrong. In many cases the system is right. By design there is no relation between one wrong reading and hundreds of other accurate ones.

Fundamentally the systems are sound. They use proven components and perform no mysterious acts. Their readings can be no more accurate than that given out by the basic measuring circuits. Somehow some of the critics expect the information system to take an erroneous signal and make it "straighten up and fly right."

Original presentation was before the American Petroleum Institute, Division of Refining Meeting, Philadelphia, May 15, 1957. ##

About the Author

JAMES McDONALD received his B.S. degree in mechanical engineering from Yale University in 1937, then studied chemical engineering at Brooklyn Polytechnic Institute. In 1940 he joined Tidewater Oil Company and spent 14 years at the Bayonne, N. J. refinery. He was then transferred to C F Braun and Company as a member of the Delaware Flying-A refinery design group. In June 1956 he was made assistant manager of the Delaware City refinery.

Take a look at . . .

American Oil Company's New Yorktown Refinery

This ultra-modern plant is ideally suited to the area and for future expansion.

TO INSURE a bright future for its Yorktown (Virginia) refinery, American Oil Company wanted the most refinery for its investment. Also included in the preliminary plans were provisions for future expansion. Starting with 35,000 bpsd crude capacity, Amoco hoped to double capacity within five years. Careful planning to permit expansion to keep costs low and prevent interference with refinery operations were made from the very beginning.

The number 35 plays an important part in this story of the first large industrial plant in a historic area, famed for its fishing waters and largely agricultural. The new refinery cost approximately $35 million, charged 35,000 bpsd, employs 350 people and was dedicated less than two months before the 350th anniversary of the first permanent settlement in the U. S. at nearby Jamestown.

Going on stream in December, 1956, this ultra-modern Yorktown refinery is conveniently located near the mouth of the York River on the Virginia peninsula. The York River is a natural channel, 40 feet deep and eliminated the need for elaborate dredging. A 3000-foot pier was built to accommodate supertankers. Proximity to municipal supplies of fresh water and electric power, as well as the local labor supply, makes this site further ideally suited for a completely integrated refinery. Providing better service for Amoco's marketing outlets in this area further emphasizes the planning in this site selection.

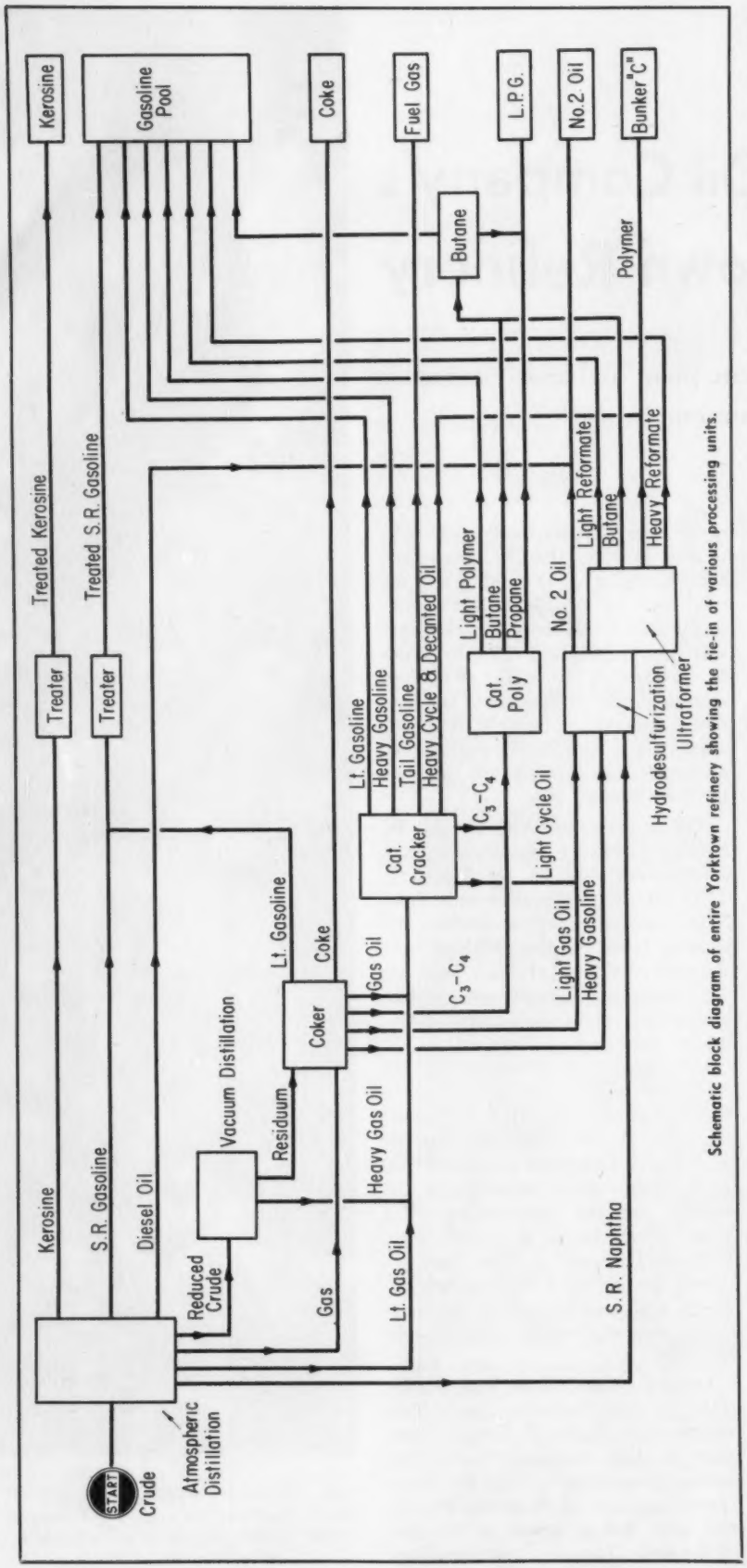
Two months after announcement of the site selection was made September 25, 1953, the Chesapeake and Ohio Railroad began building a seven-mile spur to provide freight service to the site. Preliminary site clearance was started May 25, 1954, by Wiley N. Jackson of Roanoke, Va. Four months later, Tidewater Construction Company of Norfolk, Va., was awarded a $1,750,000 engineering, dredging and construction contract for the 3000-foot pier.

The prime contractor, The M. W. Kellogg Company, was awarded the construction contract on March 2, 1955, for the combination unit, catalytic cracking, polymerization and treating facilities. Also included were the construction of auxiliary facilities, e.g., power and lighting systems, laboratory and operations building, warehouses, maintenance shop, etc.

Construction of storage capacity of 3,770,000 barrels was awarded to Chicago Bridge and Iron Company. On April 5, 1955, Virginia Electric and Power Company purchased 120 acres from Amoco adjacent to the refinery for the construction of a steam power plant. A month later, Lummus Company of New York received the contract for engineering, design and construction of the four-drum, semi-continuous, delayed coking unit.

Ground was broken August 18, 1955 for the combination unit. Two months later, Ralph M. Parsons Company of Los Angeles, received the contract for construction of the Ultraformer and gas oil hydrodesulfurization unit. Not on stream at the time of the dedication, the hydrodesulfuri-

Night view of the delayed coking unit at Amoco's Yorktown refinery. The unit recovers valuable gasoline and gas oil for further processing. It is 247 feet tall.



Schematic block diagram of entire Yorktown refinery showing the tie-in of various processing units.

zation unit is expected to commence operation soon.

First delivery of crude oil was made July 13, 1956, when the T-2 tanker San Juan tied up at the newly-finished pier to discharge its cargo of Venezuelan 26-gravity Tia Juana crude.

The combination unit went on stream December 23, 1956, producing the first gasoline ever refined in Virginia. The administration building was occupied December 20, 1956, and the coking unit began operations a week later.

The new refinery, with one unit still to be completed, is expected to undergo continuous expansion. Fluor Corporation of Los Angeles has been awarded a contract for a gas treating and sulfur recovery plant, to produce 50 tons of liquid sulfur daily. Ground was broken in June and completion scheduled for November, 1957.

Of the 1300 acres in the refinery site, less than half is in actual use at the present time.

Products. Particular emphasis is placed on manufacture of high-octane, unleaded premium gasoline. Through conversion to aromatics in the Ultraformer, a rise in octane number of 95 to 100 may be expected with only slight loss of lower grade gasoline. Other finished products include housebrand gasoline, kerosine, fuel oil (No. 2 and Bunker C), LPG and coke. The future addition of an alkylation unit for aviation blending stocks is planned, but there are no definite plans for this in the immediate future. Surplus fuel gas is metered to Virginia Electric and Power Company.

Processes. Generally the units are of conventional design with ample provision made for future expansion and the addition of other processing units.

The Combination Unit includes the atmospheric crude distillation unit, vacuum distillation, fluid catalytic cracking unit and gas-recovery section. Intermediate tankage is available for unfinished products from the various units, permitting independent operation for limited periods.

Also included in this combination unit is the catalytic polymerization unit and the kerosine and gasoline

treating units. Considered a part of the combination unit is the catalytic reforming process.

The Hydrodesulfurization Unit, which is to come on stream soon, will be used in feed preparation for the catalytic reformer.

The Coking Unit is of special interest because of the nearness of the ultimate user of the coke product. The unit has produced about 100,000 tons of coke up till dedication and is currently producing about 600 tons daily.

The unit consists of four coke drums, 95 feet high and 17 feet-6 inches in diameter, topped with drilling units, for coke removal. The overall height of the structure is 234 feet. The unit was designed for a charge mixture of vacuum reduced crude with 25 percent Conradson carbon, an API gravity of 6.1 degrees, and an SFS viscosity of 6000 at 210 F. It was also designed to process a variety of stocks at different recycle ratios to meet required flexibility.

Hydraulic de-coking equipment is used and the coke is moved by earthmover to the Virginia Electric and Power Company plant adjacent to the refinery. The coke is stockpiled at VEPCO and will be ground and pulverized preparatory to firing in the generation system.

The Utility System is unique in that the refinery's power station is the hub for most of its utility systems. Steam generating facilities consist of two watertube boilers having a capacity of 100,000 pounds per hour each of outdoor type construction. Separate electric power feeder systems to the various units are utilized. The proximity of Virginia Electric and Power Company's generating facilities permit the use of inexpensive across-the-line starters. Short feeders prevent excessive voltage drop and the utility company's power system has sufficient capacity to absorb these sudden large loads.

Water from the York River is used on a once-through basis for cooling. Three 25,000 gallon-per-minute pumps and a 42-inch concrete-lined cast iron line carry water to the refinery. Present cooling water facilities have capacity for a limited plant expansion and provisions have been made for additional facilities when needed.

Elaborate treating facilities have been provided for the refinery effluent streams. The complete system provides for disposal of surface runoff, oily water, tanker ballast, sanitary drainage, boiler blowdown, process waters, sour gases, combustible waste gases, flue gases, and spent caustic.

Surface runoff waters are treated in a settling basin. Suspended particles settle out as waters pass through a dike labyrinth. This clear water effluent then passes an oil baffle and skimming trough and through a hay filter before entering the York River.

Oily water is treated in an API separator. Where necessary to restore oxygen, a five-acre oxidation pond is used. Oxidation can be accelerated by agitating the water by pumping. Baffles and skimming facilities remove oil from secondary oil and water separation. pH is controlled by sampling the API separator effluent water continuously and when necessary, additives are used to maintain desired pH value. Cooling water flows into the 60-inch cooling water outfall line and discharges 3000 feet out in the York River 30 feet below the surface.

A 20,000-barrel concrete holding basin accommodates ballast water occasionally pumped from tankers. Oil is trapped and water, depending on its condition, moves either to the settling basin or treating facilities.

Blowdown from steam-generating facilities is quenched, collected and pumped into the settling basin where sludge settles out. Effluent from the sanitary system is also treated.

Process reflux waters are combined and steam-stripped to drive off sulfides, mercaptans and hydrocarbon vapors, which are collected and burned. These streams are passed over a cooling tower to render phenols harmless by oxidation and restore oxygen content.

The feed to the catalytic-polymerization unit contains about 2000 pounds per hour of hydrogen sulfide. This material is removed by the hydrogen sulfide absorber and flared.

Start-Up Troubles. Mark C. Hopkins, manager of the Yorktown refinery, reported very little start-up problems. There were some minor bearings and pump failures. However, *none* of these difficulties occurred in such a way as to prevent continuous operation.

Hopkins attributed this smooth start-up not only to the design, construction and engineering but also in large measure to the skill and diligence of the personnel and to the intensity of their training. Despite the fact that only 50 of the 350 employes had any previous experience in refinery work, the new plant went on stream with a minimum of trouble.

With such elaborate planning and provision for the future the Yorktown refinery of American Oil Company certainly does have a bright future.

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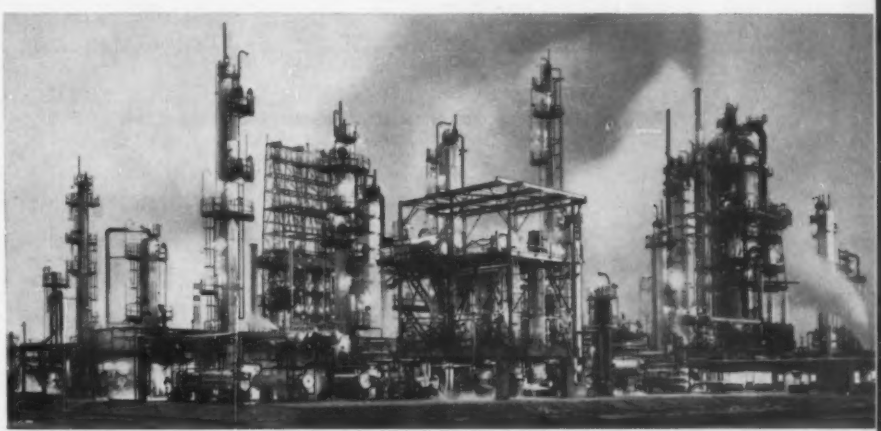

This is Amoco's combination unit at Yorktown refinery, an example of how highly developed technical processes are integrated into a single processing area or unit. It combines crude distillation, catalytic cracking, catalytic polymerization and product treating.

Liquid and Gas ΔP by Nomogram

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Reynolds Metals Company
Louisville, Ky.

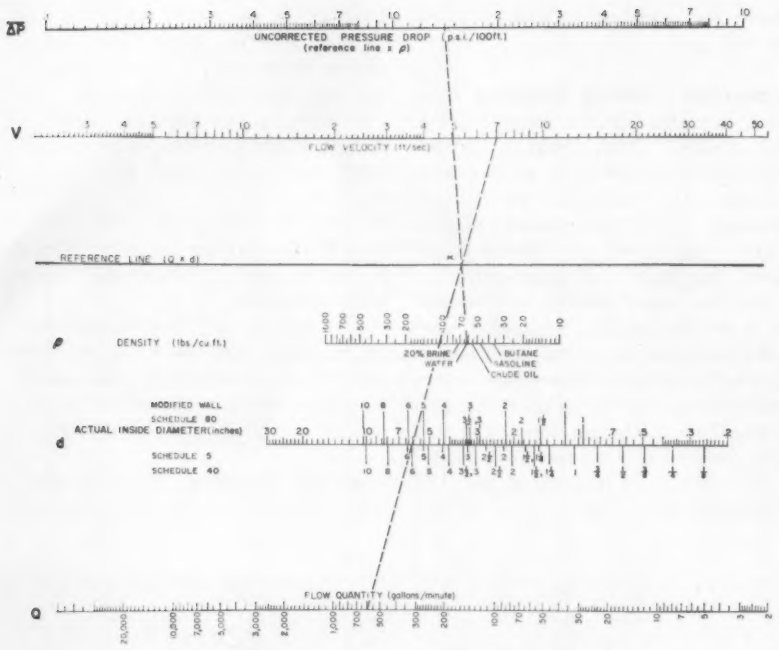

FIGURE 1a—How to calculate uncorrected pressure drop for liquid flow.

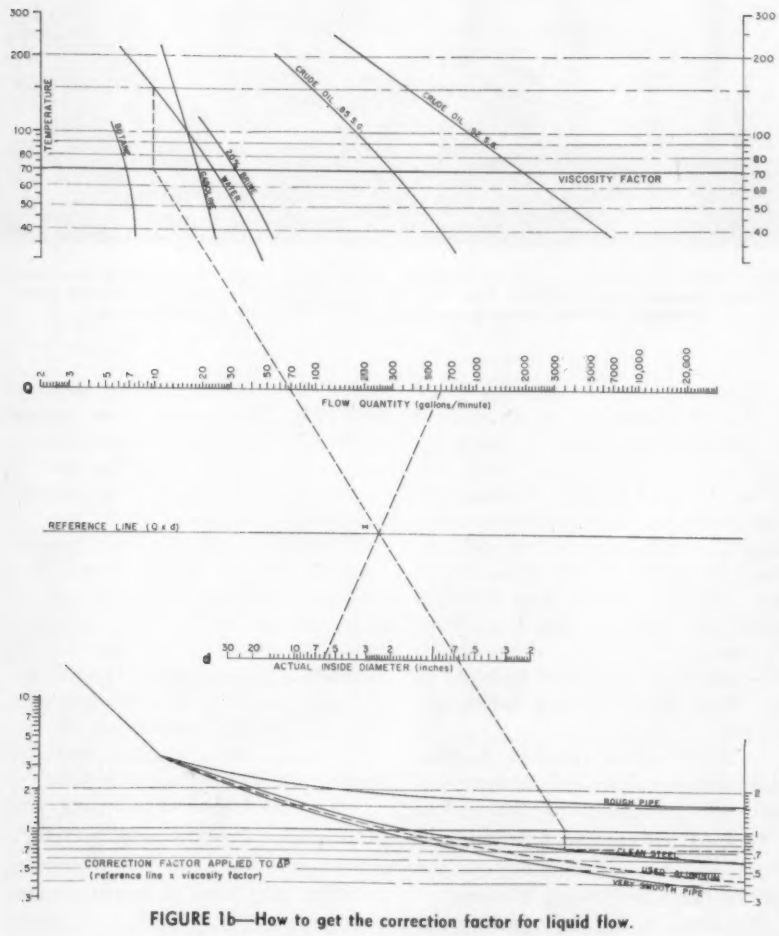

FIGURE 1b—How to get the correction factor for liquid flow.

LIQUIDS

Figures 1a and 1b are used for determining the pressure drop in piping caused by friction of liquids flowing through a straight pipe. These charts are for turbulent flow only (Reynolds number > 2100). The corrected pressure drop, ΔP, in psi per 100 feet is expressed as follows:

$$\Delta P = 0.518\frac{f\rho V^2}{d} = 0.0864\frac{f\rho Q^2}{d^5}$$

Problem. Find the fluid velocity and pressure drop per 100 feet of 6-inch standard steel pipe carrying 600 gpm of water 150 F.

Rapid Estimate. On Figure 1a, connect 600 gpm on Q scale with 6-inch

(steel pipe) on left side of d scale, extending line to Flow Velocity scale which indicates 7 feet per second. Mark the intercept (x) with the reference line and then connect x with "water" on ρ (density) scale, extending line to $\overline{\Delta P}$ line. Uncorrected Pressure Drop indicates a value of 1.40 psi per 100 feet of pipe.

Accurate Solution. On Figure 1b, connect 600 gpm on Q scale with 6.065 inch (I.D.) on the d scale, marking intercept (x) on reference line. Next go to the uppermost graph on Figure 1b to the curve representing the liquid being used. On this curve, at the temperature of the flowing fluid, extend a vertical line to the viscosity factor line. Connect this intersection with x and extend this line to the Correction Factor Line (value of 1.0). Now extend this line vertically to the desired pipe classification, then horizontally to get the correction factor. In the case of this problem the correction factor is 0.7. The corrected pressure drop is then $\Delta P = 1.40 \times 0.7 = 0.98$ psi per 100 feet.

GASES AND VAPORS

Figures 2a, 2b and 2c comprise a nomograph for determining the pressure drop of gases flowing in straight pipes. The corrected pressure drop ΔP in psi per 100 feet is expressed as follows:

$$\Delta P = \frac{143.8\, f\, \rho\, (V')^2}{d} = 0.00134\, \frac{f\, v\, w^2}{d^5}$$

I. How to Get the Specific Volume. Figure 2a can also be used to determine the specific volume of gases v from the molecular weight M, the pressure p and temperature t.

Problem: Find the specific volume of methane gas at standard conditions; atmospheric pressure and 60 F.

Solution: Use Figure 2a. Connect 60 F on scale t with 0 on scale P, extending the line to the intercept (x) of the reference line. Connect x with the value for methane (molecular weight 16) on line M, marking the intercept on line v. On v read 23 cubic feet per pound as the specific

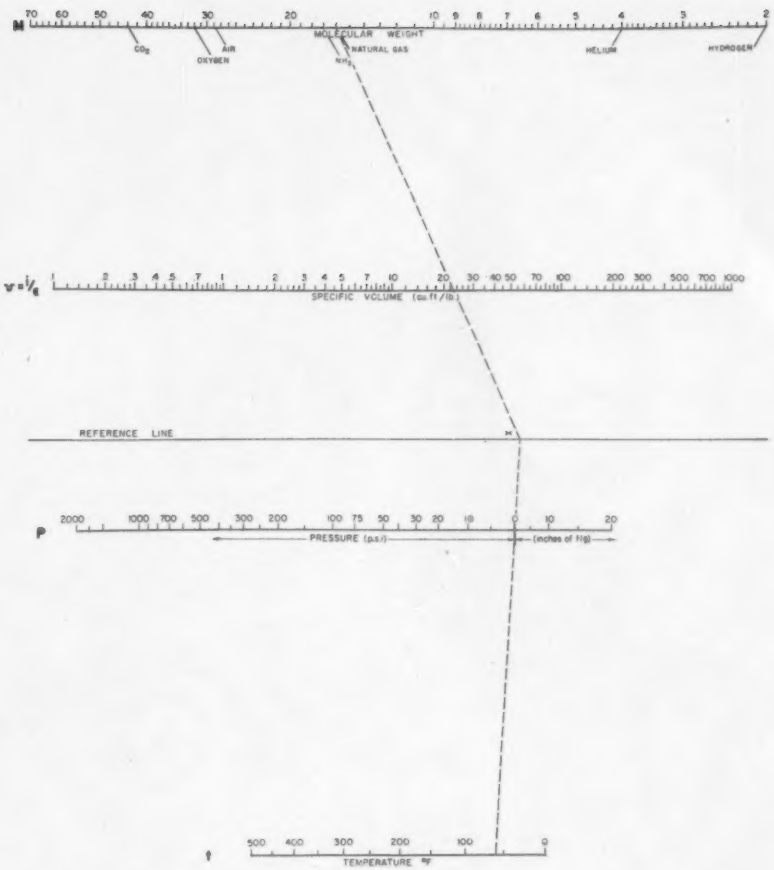

FIGURE 2a—A rapid method of obtaining the specific volumes of gases and vapors.

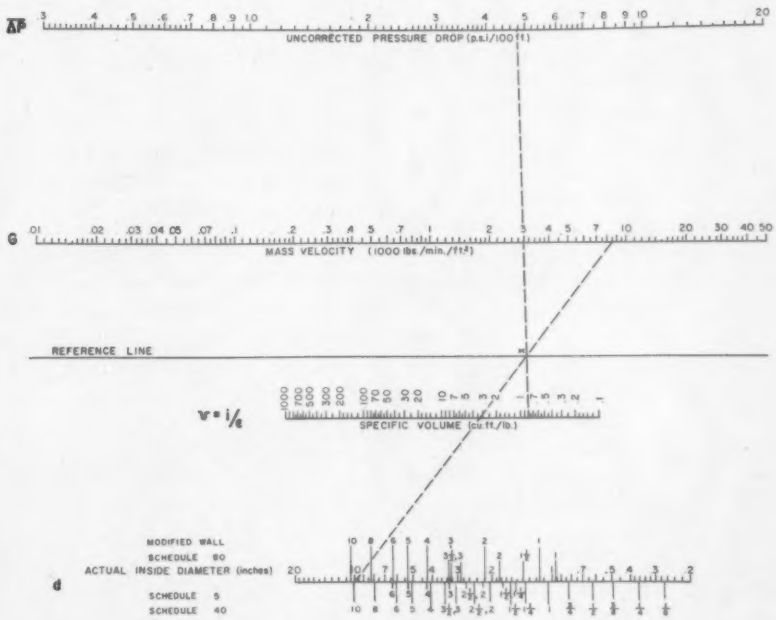

FIGURE 2b—How to calculate the uncorrected pressure drop for gases and vapors.

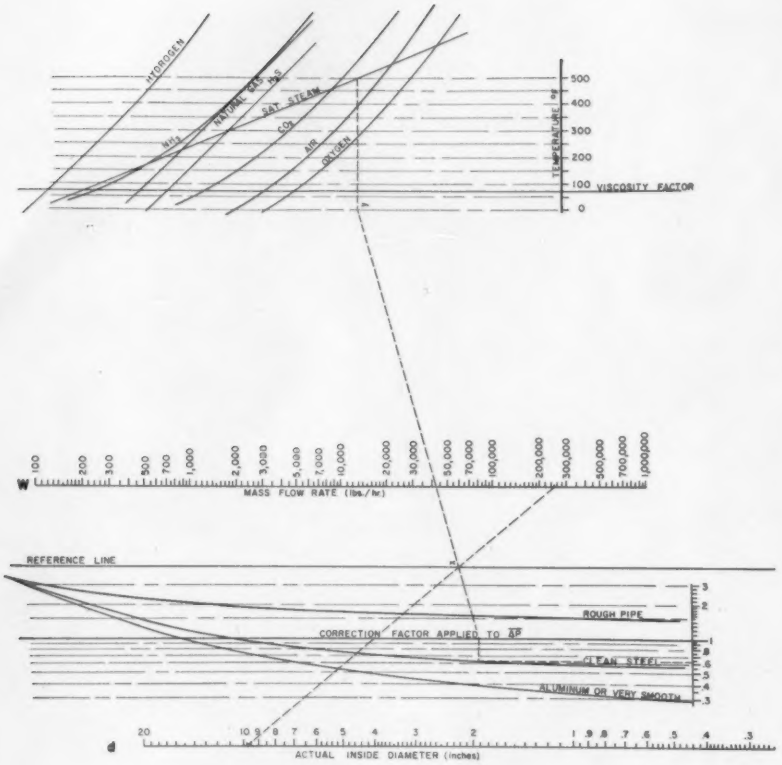

FIGURE 2c—Correction factors for gas and vapor flow.

volume of methane under standard conditions.

II. How to Get ΔP for Vapors and Gases.

Figure 2b provides a rapid estimate of pressure drop in straight piping handling gas. Chart 2c should be used for more accurate solution using Correction Factors for pipe friction.

Problem: Find the presure drop per 100 feet of pipe and the velocity of steam carried in 10 inch Schedule 80 steel pipe at a rate of 250,000 pounds per hour at 600 psig and 500 F.

Rapid Estimate. By reference to steam tables, find the specific volume of steam as 0.79 cubic feet per pound at 600 psig and 500 F.

On Figure 2b, connect 250,000 on the W scale with 9.75 inches (I.D. of Schedule 80 steel pipe) on the d scale, extending the line to 8.5 × 1000 on the mass velocity scale. Mark the intercept (x) of the extended line on the reference line. Note that the mass velocity was 8.5 × 1000 lbs./min./sq. ft. If this is multiplied by the specific volume of 0.79 cubic feet per pound the result will be the velocity of 6700 feet per minute which is one of the answers desired.

To get the uncorrected pressure, connect x with 0.79 on the v scale extending the line to the Uncorrected Pressure Drop line marking the intercept which is $\overline{\Delta P}$ = 4.8 psi per 100 feet.

Accurate Solution. On Figure 2c, connect 250,000 on w scale with 9.56 inches on d scale marking intercept (x) on the reference line. Go down vertically from the saturated steam at 500 F, to the Viscosity Factor line at intercept (y). Connect y with x and extend line to "Correction Factor" reference line. Draw a vertical line from the intercept to "clean steel" curve and a horizontal line from this intercept to 0.6 Correction Factor. The corrected pressure drop is 4.8 × 0.6 = 3.88 psi per 100 feet.

III. For Long Pipe Lengths.

The use of the nomographs for long gas piping systems may require corrections for the change in gas pressure through the piping. This can be accomplished by dividing the piping length into several lengths in which the pressure drop does not exceed 15 percent of the intial pressure. Calculations are made for each section of the line. Calculations for liquid lines do not generally require such correction.

NOMENCLATURE

- f = Fanning friction coefficient
- ρ = 1/v = fluid density in lbs. per cu. ft.
- V = average fluid velocity in feet per second
- V′ = average fluid velocity, 1000 feet per minute
- Q = fluid flow in gallons per minute
- w = mass rate of flow, lbs. per hour
- d = inside diameter of pipe, inches.
- ΔP = pressure drop, psi per 100 feet

ACKNOWLEDGMENT

The nomograms in this article have been adapted from the Engineering and Data Book Number 211, published by Tube Turns, Inc., Louisville, Ky.

About the Author

ROWLAND W. FLOURNOY is chief chemical engineer in the Engineering Service department of Reynolds Metals Co., Louisville. In this capacity he provides engineering services for the chemical processing and petroleum industries. Flournoy received his B.S. degree in chemical engineering in 1935 from Kansas State College, then in 1936 he joined Colgate Palmolive Co. where he spent the next six years. In 1942 he joined Spencer Chemical Co. as a technical supervisor, then in 1945 he moved to Corn Products Refining Co. where he remained for the 12 years prior to becoming associated with Reynolds Metals Co.

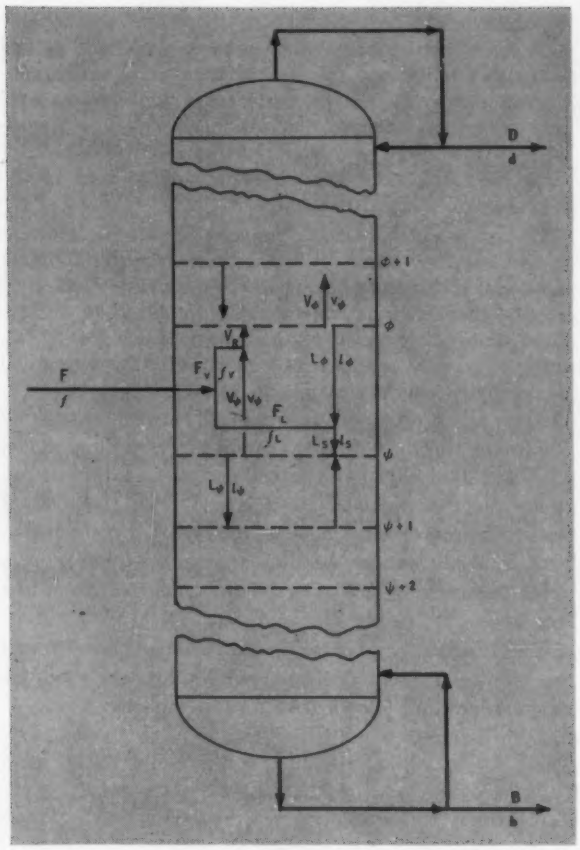

FIGURE 1—Here are the notations which are used to account for the partial vaporization of the feed between its bubble and dew points.

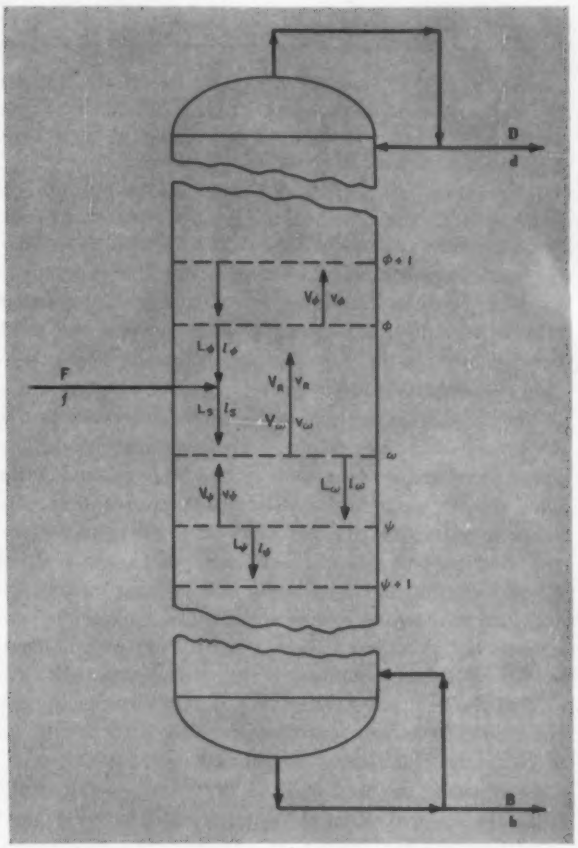

FIGURE 2—When the feed is a subcooled liquid, these are the terms which are used to figure minimum reflux.

How to Figure Minimum Reflux

You do not need to assume constant relative volatility nor constant molal overflow to calculate minimum reflux in multicomponent distillation by this method.

James B. Bachelor
Holmes and Narver, Incorporated
Los Angeles

A PRACTICAL METHOD is described for the accurate calculation of minimum reflux in multicomponent distillation systems. This method is not based on the usual limiting assumptions of constant relative volatility and constant molal overflow. The typical industrial design problem cannot be solved reliably with these assumptions.

The new method proposed here employs a relaxation technique. It does not attempt the solution in a single complex step. Instead it applies simple successive steps that converge with any degree of accuracy required to the true minimum reflux. Though the development of the method is quite involved, the application of the method is a simple numerical procedure with a minimum dependence on the experience of the operator.

If reflux is varied in the distillation process, a specified separation between two key components of a mixture can be maintained by varying the number of stages. A lower limit of reflux is reached as the stage requirements become infinite in each section of the tower.

The minimum reflux is a most useful quantity as it provides a basis for the selection of a reasonable operat-

ing reflux for a complete design of the tower. Despite the value of the minimum quantity, rigorous calculation methods[2, 9, 13] are seldom applied because of their cumbersome and time-consuming procedures.

The efforts of most of the investigators in this field have been directed toward the development of an average mathematical model that would hopefully represent all multicomponent distillation problems. But as a result of the wide range of conditions introduced by non-constant relative volatility, non-constant molal overflow and product distribution, the approximate methods[1, 5, 7, 8, 10, 12, 14, 15] may give unsatisfactory results.

The relaxation technique recognizes the inability to define an adequate average mathematical model for many physical processes such as this one. Instead it defines simple successive mathematical models that converge to represent the real physical problem to any required degree of accuracy. Because of simple features that result from the application of successive models, the accurate solution of minimum reflux in multicomponent systems becomes practical. A most important and novel feature of the new method is that calculations are initiated at the feed point. This has not only intuitive appeal, but results in an inherent simplification of the treatment of feed-zone conditions and product distribution.

Considering the feed point as the starting point in the calculations, it is natural to number theoretical trays away from the feed-zone in each section. To differentiate between sectional feed trays, the rectifying feed tray is designated ϕ and the stripping feed tray is designated Ψ. Trays ϕ and Ψ are both immediately adjacent to the feed entry except for sub-cooled liquid or superheated vapor feed. These feeds are considered to contact first a flash tray that is located between trays ϕ and Ψ. Superheated vapor first contacts flash tray θ and subcooled liquid first contacts flash tray ω. The advantages of this treatment will be discussed later.

Theory. According to distillation theory, separations may be considered as consisting of two classes. Class I separations are those in which all of the components in the feed are distributed to both the top and bottom products. Binary mixtures belong to this class, and as with binary mixtures, the constant composition zone includes trays adjacent to the feed entry as well as an infinite number of trays on either side of the feed entry. Though compositions remain constant in this zone, molal overflow changes across the feed zone. If the feed is superheated-vapor, or subcooled-liquid, an additional change in molal overflow occurs across the flash tray. The composition of the liquid and vapor phases of the feed are respectively identical with the liquid and vapor compositions in the constant composition zones except for superheated-vapor or subcooled-liquid feeds.

Class II separations are those in which there are components in the feed that do not appear in both products at minimum reflux. Constant composition zones do not appear in a section until the non-distributed components have been fractionated out. Stream compositions as well as temperatures and molal overflow may change considerably over the intermediate trays between the feed zone and the constant composition zone. The compositions of the liquid and vapor phases of the feed differ from the liquid and vapor stream compositions in the feed zone for all feed conditions.

Class I separations have rigorous analytical solutions as discussed by others.[13, 15] But most of the important industrial separations belong to Class II. The method to be described is primarily intended for Class II separations, though it solves Class I separations accurately in a single step. This results because the initial mathematical model treats each separation as though it were Class I. Deviations or residuals are observed between calculated conditions and the conditions implied by the initial model for Class II separations. Subsequent steps take into account the deviations of the Class II from the Class I separations by considering that the constant composition zone in each section may be approached closely at a point successively one tray further removed from the feed zone.

The constant component quantities that flow through the infinite trays of constant composition are given by the relationships[3] shown here for convenience.

$$l_{c,RP} = \frac{d_c\left(\frac{L}{VK_c}\right)_{RP}}{1-\left(\frac{L}{VK_c}\right)_{RP}} \qquad (1)$$

$$v_{c,SP} = \frac{b_c\left(\frac{VK_c}{L}\right)_{SP}}{1-\left(\frac{VK_c}{L}\right)_{SP}} \qquad (2)$$

The factors $\left(\frac{L}{VK_{HK}}\right)_{RP}$ and $\left(\frac{VK_{LK}}{L}\right)_{SP}$ are always less than unity.

If either of these factors for a component appear to equal or exceed unity, the component is simply not distributed to either the constant composition zone or the section product.

Absorption and stripping factor equations[4, 6, 11] though customarily written for each section of the operating tower with finite trays, may also be applied to each section of the tower with infinite trays at the minimum reflux condition. The quantity of a distributed component in the liquid from any rectifying tray or vapor from any stripping tray, is given respectively by

$$l_{c,\phi+n} = d_c\left[\left(\frac{L}{VK_c}\right)_{\phi+n} + \left(\frac{L}{VK_c}\right)_{\phi+n}\left(\frac{L}{VK_c}\right)_{\phi+n+1} + \ldots\right] \qquad (3)$$

$$v_{c,\Psi+m} = b_c\left[\left(\frac{VK_c}{L}\right)_{\Psi+m} + \left(\frac{VK_c}{L}\right)_{\Psi+m}\left(\frac{VK_c}{L}\right)_{\Psi+m+1} + \ldots\right] \qquad (4)$$

where n or m is any number 0, 1, 2, . . .

These are observed to be infinite series of individual

tray absorption or stripping factors, hereafter referred to simply as *tray factors*.

For a Class I separation, all the tray factors in Equations (3) or (4) are identical and the series are infinite geometric progressions whose sums are identical to Equations (1) and (2). This is not true for Class II separations which have a finite number of the tray factors adjacent to the feed zone in either one or both sections of the tower that differ from the remaining tray factors by some finite amount.

The infinite series in Equations (3) and (4) are shown as summed up in a succession of terms in the equations which follow. Inspection will show that each successive sum considers that the infinite trays of constant conditions begin successively one tray further away from the feed zone. The initial sum in each equation represents the minimum reflux conditions for a Class I separation exactly. Experience has shown that the usual Class II separation is accurately represented within the first few terms of each succession.

$$I_{c,\phi}{}^{i} = \left(\frac{l_{c,\phi}}{d_c}\right)^{i} = \left\{ \frac{\left(\frac{L}{VK_c}\right)^{\circ}_{RP}}{1-\left(\frac{L}{VK_c}\right)^{\circ}_{RP}} \; ; \; \frac{\left(\frac{L}{VK_c}\right)'_{\phi}}{1-\left(\frac{L}{VK_c}\right)'_{RP}} \; ; \right.$$
$$\left. \left(\frac{L}{VK_c}\right)''_{\phi} + \frac{\left(\frac{L}{VK_c}\right)''_{\phi}\left(\frac{L}{VK_c}\right)''_{\phi+1}}{1-\left(\frac{L}{VK_c}\right)''_{RP}} \; ; \; \ldots\ldots \right\} \quad (3a)$$

$$J_{c,\psi}{}^{i} = \left(\frac{v_{c,\psi}}{b_c}\right)^{i} = \left\{ \frac{\left(\frac{VK_c}{L}\right)^{\circ}_{SP}}{1-\left(\frac{VK_c}{L}\right)^{\circ}_{SP}} \; ; \; \frac{\left(\frac{VK_c}{L}\right)'_{\psi}}{1-\left(\frac{VK_c}{L}\right)'_{SP}} \; ; \right.$$
$$\left. \left(\frac{VK_c}{L}\right)''_{\psi} + \frac{\left(\frac{VK_c}{L}\right)''_{\psi}\left(\frac{VK_c}{L}\right)''_{\psi+1}}{1-\left(\frac{VK_c}{L}\right)''_{SP}} \; ; \; \ldots\ldots \right\} \quad (4a)$$

where i refers to the successive cycle number 0, 1, 2, . . . as do the prime marks on each term. Referring to Equations (3), (3a), (4), and (4a), it may be observed that $I^{o}_{c,\phi+j}$ is constant for all j, that $I'_{c,\phi+j}$ is constant for all $j \geqq 1$, and in general $I^{n}_{c,\phi+j}$ is constant for all $j \geqq n$. Likewise, $j^{m}_{c,\psi+j}$ is constant for all $j \geqq m$.

In general, $I'_{c,\phi+j-1} = \left(\frac{L}{VK_c}\right)^{i}_{\phi+j-1} [I'_{c,\phi+j} + 1]$ for all i and for all $j \geqq 1$. Also $J'_{c,\psi+j-1} = \left(\frac{VK_c}{L}\right)^{i}_{\psi+j-1} [J'_{c,\psi+j}]$ for all i and for all $j \geqq 1$.

RECOVERIES AND RELATIVE RECOVERIES

Effective working equations for the method are based on newly defined terms of recovery and relative recovery that are readily subject to numerical analysis. The new terms bear a simple relationship to the stream quantities from each section of the tower as given by Equations (3a) and (4a). For example, rectifying recovery for the general component, G_c, is equal to $\frac{l_{c,\phi}}{l_{c,\phi}+d_c} = \frac{I_{c,\phi}}{1+I_{c,\phi}}$ where $I_{c,\phi}$ is simply $\frac{l_{c,\phi}}{d_c}$. Relative rectifying recovery is the rectifying recovery for the general component, relative to that for the heavy key component.

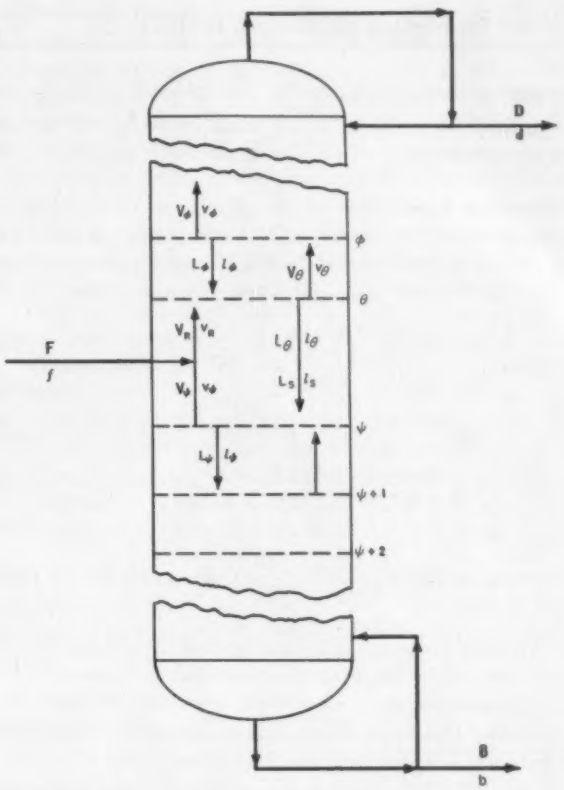

FIGURE 3—Here are the notations for a superheated vapor feed.

In relaxation form $g^{i}_{c} = \frac{I^{i}_{HK,\phi}}{1+I^{i}_{HK,\phi}} \Big/ \frac{I^{i}_{c,\phi}}{1+I^{i}_{c,\phi}}$ (5)

and is used in conjunction with Equation (3a). Stripping recovery for the general component, U_c, is equal to $\frac{v_{c,\psi}}{v_{c,\psi}+b_c} = \frac{J_{c,\psi}}{1+J_{c,\psi}}$ where $J_{c,\psi}$ is simply $\frac{v_{c,\psi}}{b_c}$. Relative stripping recovery is the stripping recovery for the general component relative to that for the heavy key component. In relaxation form $u^{i}_{c,\psi} = \frac{J^{i}_{c,\psi}}{1+J^{i}_{c,\psi}} \Big/ \frac{J^{i}_{HK,\psi}}{1+J^{i}_{HK,\psi}}$ (6), and is used in conjunction with Equation (4a).

The numerical value of a recovery term is positive and never exceeds unity, and except for a non-distributed component is always less than unity. Relative recoveries are positive, and have unlimited range.

Relative recoveries for Class I separations may be seen to be numerically equal to the relative volatilities at the feed-zone temperature by substituting the first term in Equations (3a) and (4a) into Equations (5) and (6) respectively. For Class II separations the relative recoveries can be shown to tend to equal or exceed the numerical values of the relative volatilities at each respective constant composition zone.

In a superheated vapor or subcooled liquid feed, the

recovery terms $\overline{G}_C = \frac{l_{C,\phi}}{l_{C,\phi} + d_C}$ or $\overline{U}_C = \frac{v_{C,\omega}}{v_{C,\omega} + b_C}$ are employed in addition to the usual recovery and relative recovery terms.

Working Equations—Material balances in terms of recoveries give the quantities of a component in the feed-zone and product streams for a partially vaporized feed. Refer to Figures 1, 2, and 3 for stream notations.

$$l_{C,\phi} = \frac{f_{C,V} G_C + f_{C,L} G_C U_C}{1 - U_C G_C} \quad (7a)$$

$$l_{C,S} = \frac{f_{C,V} G_C + f_{C,L}}{1 - U_C G_C} \quad (7b)$$

$$v_{C,R} = \frac{f_{C,V} + f_{C,L} U_C}{1 - U_C G_C} \quad (7c)$$

$$v_{C,\psi} = \frac{f_{C,V} U_C G_C + f_{C,L} U_C}{1 - U_C G_C} \quad (7d)$$

$$d_C = \frac{(f_{C,V} + f_{C,L} U_C)}{1 - U_C G_C} (1 - G_C) \quad (7e)$$

$$b_C = \frac{(f_{C,V} G_C + f_{C,L})}{1 - U_C G_C} (1 - U_C) \quad (7f)$$

Writing Equation (7c) for both the light and heavy key, and expressing light key recoveries in terms of heavy key recoveries and relative recovery for the light key gives two equations. These may be solved simultaneously for heavy key recovery as a function of relative recovery of the light key. Solving Equation (7c) simultaneously for the two key components gives

$$U_{HK} = \frac{-\rho \pm \sqrt{\rho^2 - 4\mu\zeta}}{2\mu} \quad (7g)$$

where $\mu = f_{HK,L} \frac{u_{LK}}{g_{LK}} (d_{LK} - f_{LK,L}) - f_{LK,L} u_{LK} (d_{HK} - f_{HK,L})$

$$\rho = (d_{LK} - f_{LK,V})(d_{HK} - f_{HK,L}) - (d_{HK} - f_{HK,V})(d_{LK} - f_{LK,L})\frac{u_{LK}}{g_{LK}} + f_{LK,L} f_{HK,V} p_{LK} - \frac{f_{HK,L} f_{LK,V}}{g_{LK}}$$

$$\zeta = (d_{HK} - f_{HK,V})\frac{f_{LK,V}}{g_{LK}} - (d_{LK} - f_{LK,V}) f_{HK,V}$$

$$G_{HK} = \frac{(d_{HK} - f_{HK,V}) - f_{HK,L} U_{HK}}{(d_{HK} - f_{HK,L}) U_{HK} - f_{HK,V}} \quad (7h)$$

If the feed is liquid at its bubble-point or vapor at its dew-point, one of the terms $f_{C,V}$ or $f_{C,L}$ becomes zero in the feed-zone and product stream equations. For these limiting cases, the heavy key recoveries become respectively for liquid feed at its bubble-point,

$$U_{HK} = \frac{d_{LK} b_{HK}\left(\frac{g_{LK}}{u_{LK}}\right) - d_{HK} b_{LK}}{f_{LK} b_{HK} g_{LK} - f_{HK} b_{LK}} \quad (8a)$$

$$G_{HK} = \frac{f_{HK} U_{HK} - d_{HK}}{b_{HK} U_{HK}} \quad (8b)$$

and for vapor feed at its dew-point,

$$U_{HK} = \frac{f_{HK} b_{LK} - \frac{f_{LK} b_{HK}}{g_{LK}}}{b_{LK} d_{HK} - b_{HK} d_{LK} \frac{u_{LK}}{g_{LK}}} \quad (9a)$$

$$G_{HK} = \frac{b_{HK}}{f_{HK} - d_{HK} U_{HK}} \quad (9b)$$

Subcooled Liquid Feed—By material balance and by considering the equilibrium relationship $l_{C,\omega} = \left(\frac{L}{VK_C}\right)_\omega v_{C,\omega}$, the feed-zone and product stream quantities for a subcooled liquid feed are given by the following equations:

$$v_{C,R} = v_{C,\omega} = \frac{f_C \overline{U}_C}{1 - \overline{U}_C G_C} \quad (10a)$$

$$l_{C,\phi} = \frac{f_C \overline{U}_C G_C}{1 - \overline{U}_C G_C} \quad (10b)$$

$$l_{C,S} = \frac{f_C}{1 - \overline{U}_C G_C} \quad (10c)$$

$$l_{C,\omega} = \left(\frac{L}{VK_C}\right)_\omega \frac{f_C \overline{U}_C}{1 - \overline{U}_C G_C} \quad (10d)$$

$$d_C = \frac{f_C \overline{U}_C}{1 - \overline{U}_C G_C} (1 - G_C) \quad (10e)$$

$$b_C = \frac{f_C}{1 - \overline{U}_C G_C} (1 - \overline{U}_C) \quad (10f)$$

The rectifying and stripping recovery for the heavy key component are obtained by solving either Equations (10e) or (10f) simultaneously for the specified quantities of the light and heavy keys in the product.

$$U_{HK} = \frac{\left(\frac{b_{HK} d_{LK} g_{LK}}{d_{HK} b_{LK} \alpha_{LK,\omega}} - 1\right) - \frac{b_{HK}(g_{LK} - 1)}{d_{HK}\left(\frac{L}{VK_{HK}}\right)_\omega}}{\frac{b_{HK} d_{LK} u_{LK} g_{LK}}{d_{HK} b_{LK} \alpha_{LK,\omega}} - 1} \quad (10g)$$

$$G_{HK} = 1 - \frac{d_{HK}}{b_{HK}}\left(\frac{L}{VK_{HK}}\right)_\omega (1 - U_{HK}) \quad (10h)$$

Combined stripping recovery for the general component is,

$$\overline{U}_C = \frac{1}{\left(\frac{L}{VK_C}\right)_\omega (1 - \overline{U}_C) + 1} \quad (10i)$$

Superheated Vapor Feed—By material balance and by considering the equilibrium relationship the feed zone quantity and product stream for a superheated vapor feed are given by the following equations:

$$l_{C,\phi} = l_{C,S} = \frac{f_C \overline{G}_C}{1 - U_C \overline{G}_C} \quad (11a)$$

$$v_{C,R} = \frac{f_C}{1 - U_C \overline{G}_C} \quad (11b)$$

$$v_{C,\psi} = \frac{f_C U_C \overline{G}_C}{1 - U_C \overline{G}_C} \quad (11c)$$

$$v_{C,\phi} = \left(\frac{VK_C}{L}\right)_\phi \frac{f_C \overline{G}_C}{1 - U_{CG}} \quad (11d)$$

$$d_C = \frac{f_C (1 - \overline{G}_C)}{1 - U_C \overline{G}_C} \quad (11e)$$

$$b_C = \frac{f_C \overline{G}_C (1 - U_C)}{1 - U_C \overline{G}_C} \quad (11f)$$

The rectifying and stripping recovery for the heavy key component are obtained by simultaneous solution of either Equations (11e) or (11f) for the two specified key components.

The rectifying and stripping recovery for the heavy key are,

$$U_{HK} = \frac{\left(\frac{b_{HK} d_{LK} g_{LK}}{d_{HK} b_{LK} \alpha_{LK,\phi}} - 1\right) - \frac{b_{HK}}{d_{HK}}\left(\frac{VK_{HK}}{L}\right)_\phi (g_{LK} - 1)}{\frac{b_{HK}}{d_{HK}} \frac{d_{LK}}{b_{LK}} \frac{u_{LK} g_{LK}}{\alpha_{LK,\phi}} - 1} \quad (11g)$$

$$G_{HK} = 1 - \frac{d_{HK}}{b_{HK}} \frac{(1 - U_{HK})}{\left(\frac{VK_{HK}}{L}\right)_\phi} \quad (11h)$$

The combined rectifying recovery for the general component is

$$\overline{G}_o = \frac{1}{\left(\frac{VK_c}{L}\right)_\phi (1 - G_c) + 1} \qquad (11i)$$

Calculations are initiated with ease since equilibrium K values are all the data that are required to furnish the initial numerical values for relative recoveries. As relative recoveries are modified by the results of the preceding cycle, they are replaced in the equations above to give more exact stream quantities.

The numerical processes of the method account for all such heat effects by suitable heat balances. The zero-cycle calculation requires only that the liquid and vapor phase quantities of the feed be established for partially vaporized feed.

For a superheated vapor or subcooled liquid feed, a trial value of a key flash tray factor is applied in the equations with relative recoveries and relative volatilities to obtain corresponding feed-zone stream quantities and compositions. The trial flash tray factor is set by an estimated "q" value only as a guide. The actual change in overflow bears no simple relation to the "q" value; however, the method avoids this weakness in calculating the feed conditions. To make a heat balance of the streams, a specific heat-content of the feed is required so that the trial conditions fix the corresponding feed temperature. If the feed temperature is arbitrary, calculations for several feed conditions may be made to establish an optimum balance between heat and reflux requirements.

Residuals and Cycles—For the minimum reflux condition, an infinite number of theoretical tray points must be considered in each section of the tower. Only a finite number of tray factors for points in the region of the feed-zone differ a finite amount from those for the infinite number of points in the constant composition zones.

Within the mechanics of the method, numerical values are assigned for each tray factor at each theoretical tray point for all the distributed components to initiate a cycle. At the end of the cycle, any differences, or residuals between calculated numerical values and those which initiated the cycle are noted. The object in a succeeding cycle is to attempt to reduce these residuals to practically zero. All this is accomplished by a simple stepwise application of the working equations, Equations (3a) and (4a) and the process of checking tray factors.

CORRECTIONS FOR TABLE 1

Line 5: Eq. (5g) should read (7g).
Lines 5 and 7: Add superscript ° to first term on both sides.
Line 7: $\phi + j$ is a subscript.
Line 32: Eq. (7a) should read (7e).

EXAMPLE SOLUTIONS

Each cycle yields feed-zone and product stream quantities. The tray factors that go into the succeeding terms of (3a) and (4a) are calculated from these stream quantities. Though experienced operators will recognize that this is the familiar tray calculation problem, a specific procedure is defined to minimize error in the numerical procedure.

Preliminary Calculation Steps

1. Calculate condensing and reboiling temperatures for products similar to those wanted. This is the usual procedure in establishing a satisfactory operating pressure.
2. Calculate the average tower temperature as the arithmetic average of condensing and reboiling temperature.
3. Tabulate relative volatilities at temperatures ⅓ of the interval from the average to the condensing temperature, and the average to the reboiling temperature. These are zero-cycle relative recovery values $g_c°$ and $u_c°$. For a subcooled liquid or superheated vapor feed, tabulate also the relative volatilities at the average temperature.
4. Select two distributed components as light and heavy key. Specify their distribution to each product.
5. If feed is partially vaporized, 0-100 percent, calculate component quantities in feed vapor and feed liquid by a usual equilibrium flash method.

Part Vapor Feed—Table 1 lists a succession of numerical operations for a part vapor feed. The bulk of the operations require no explanation since they are only simple arithmetical relationships between data on suc-

TABLE 1
Numerical Operations
For Part Vapor Feed (0-100%)

Line	Distributed Components		Non-Distributed Components	
(1) $f_{c,V}$		Preliminary	$f_{c,V}$	Preliminary
(2) $f_{c,L}$		Preliminary	$f_{c,L}$	Preliminary
(3) $\alpha°_{c,HP}$		Preliminary	$\alpha°_{c,HP}$	Preliminary
(4) $\alpha°_{c,HP}$		Preliminary	$\alpha°_{c,HP}$	Preliminary
(5) $\left(\frac{VK_c}{L}\right)°_{\phi+j} \leq 1$	(4) × $U°_{HK}$ by Eq. (7g), (8a), or (9a)		$\left(\frac{VK_c}{L}\right)°_{\phi+j} \geq 1$	(4) × $U°_{HK}$ by Eq. (5g), (8a), or (9a)
(6) $U°_c$	(5)		$U°_k$	Unity
(7) $\left(\frac{L}{VK_c}\right)°_{\phi+j} \leq 1$	$G°_{HK}$ by Eq. (7h), (8b) or (9b)/(5)		$\left(\frac{L}{VK_c}\right)°_{\phi+j} \geq 1$	$G°_{HK}$ by Eq. (7h), (8b) or (9b)/(5)
(8) $G°_c$	(7)		$G°_c$	Unity
(9) $l°_{c,\phi}$	by Eq. (7a)		$l°_{c,\phi}$	by Eq. (7a)
(10) $d°_c$	by Eq. (7e)		—	—
(11) $b°_c$	(1) + (2) — (10)		—	—
(12) $v°_{c,\phi}$	(9) + (10) — (1)		$v°_{c,\phi}$	(9) — (1)
(13) $v°_{c,\phi}$	(9) + (10)		$v°_{c,\phi}$	(9)/(7)
(14) $v°_{c,\phi+1}$	(13)		$v°_{c,\phi+1}$	(13)/(7)
(15) $v°_{c,HP}$	(13)		$v°_{c,HP}$	Zero
(16) $l°_{c,\phi}$	(9) + (2)		$l°_{c,\phi}$	(12)/(5)
(17) $l°_{c,\phi+1}$	(16)		$l°_{c,\phi+1}$	(16)/(5)
(18) $l°_{c,HP}$	(16)		$l°_{c,HP}$	Zero
(19) $\left(\frac{VK_c}{L}\right)'_\phi$	From zero-cycle data—see instructions		$\left(\frac{VK_c}{L}\right)'_\phi$	From zero-cycle data—see instructions
(20) $\left(\frac{VK_c}{L}\right)'_{\phi+j} j > 0$	From zero-cycle data—see instructions		$\left(\frac{VK_c}{L}\right)'_{\phi+j} j > 0$	From zero-cycle data—see instructions
(21) $\left(\frac{L}{VK_c}\right)'_\phi$	From zero-cycle data—see instructions		$\left(\frac{L}{VK_c}\right)'_\phi$	From zero-cycle data—see instructions
(22) $\left(\frac{L}{VK_c}\right)'_{\phi+j} j > 0$	From zero-cycle data—see instructions		$\left(\frac{L}{VK_c}\right)'_{\phi+j} j > 0$	From zero-cycle data—see instructions
(25) $l'_{c,\phi+j} j > 0$	(20)/1 — (20)		—	—
(24) $l'_{c,\phi}$	[1 + (23)] (19)		—	—
(25) $l'_{c,\phi+1} j > 0$	(22)/1 — (22)		—	—
(26) $l'_{c,\phi}$	[1 + (25)] (21)		—	—
(27) u'_c	By Eq. (6)		—	—
(28) g'_c	By Eq. (5)		—	—
(29) U'_c	(27) × U'_{HK} by Eq. (7g), (8a) or (9a)		U'_c Unity	
(30) G'_c	(28) (32) × G'_{HK} by Eq. (7h), (8b) or (9b)		G'_c Unity	
(31) $l'_{c,\phi}$	By Eq. (7a)		$l'_{c,\phi}$	By Eq. (7a)
(32) d'_c	By Eq. (7a)		—	—
(33) b'_c	(1) + (2) — (32)		—	—
(34) $v'_{c,\phi}$	(31) + (32) — (1)		$v'_{c,\phi}$	(31) — (1)
(35) $v'_{c,\phi}$	[1 + (25)](32)		$v'_{c,\phi}$	(31)/(21)
(36) $v'_{c,\phi+1}$	(35)		$v'_{c,\phi+1}$	(35)/(22)
(37) $v'_{c,\phi+1}$	(35)		$v'_{c,\phi+1}$	(36)/(22)
(38) $v'_{c,HP}$	(35)		$v'_{c,HP}$	Zero
(39) $l'_{c,\phi}$	[1 + (25)] (33)		$l'_{c,\phi}$	(34)/(19)
(40) $l'_{c,\phi+1}$	(39)		$l'_{c,\phi+1}$	(39)/(20)
(41) $l'_{c,\phi+1}$	(39)		$l'_{c,\phi+1}$	(40)/(20)
(42) $l'_{c,HP}$	(39)		$l'_{c,HP}$	Zero
(43) $\left(\frac{VK_c}{L}\right)''_\phi$			$\left(\frac{VK_c}{L}\right)''_\phi$	
(44) $\left(\frac{VK_c}{L}\right)''_{\phi+1}$			$\left(\frac{VK_c}{L}\right)''_{\phi+1}$	
(45) $\left(\frac{VK_c}{L}\right)''_{\phi+j} j > 1$	From one-cycle data—see instructions		$\left(\frac{VK_c}{L}\right)''_{\phi+j} j > 1$	From one-cycle data—see instructions
(46) $\left(\frac{L}{VK_c}\right)''_\phi$			$\left(\frac{L}{VK_c}\right)''_\phi$	
(47) $\left(\frac{L}{VK_c}\right)''_{\phi+1}$			$\left(\frac{L}{VK_c}\right)''_{\phi+1}$	
(48) $\left(\frac{L}{VK_c}\right)''_{\phi+j} j > 1$			$\left(\frac{L}{VK_c}\right)''_{\phi+j} j > 1$	
(49) $l''_{c,\phi+j} j > 1$	(45)/1 — (45)		—	—
(50) $l''_{c,\phi+1}$	[1 + (49)] (44)		—	—
(51) $l''_{c,\phi}$	[1 + (50)] (43)		—	—
(52) $l''_{c,\phi+j} j > 1$	(48)/1 — (48)		—	—
(53) $l''_{c,\phi+1}$	[1 + (52)] (47)		—	—
(54) $l''_{c,\phi}$	[1 + (53)] (46)		—	—
(55) u''_c	By Eq. (6)		—	—
(56) g''_c	By Eq. (5)		—	—

cessive lines. Other than simple line operations are explained and illustrated in the example.

The calculation steps for minimum reflux with a part vapor feed are described and at the same time illustrated by a numerical example. The numerical results are listed in Table 2.

The tower is an alkylate debutanizer at 80 psia with a part vapor feed at 180 F. 6 moles of nC_4 are specified in the bottom product, and 13 moles of iC_5 are allowed in the top product.

Preliminary steps have established that the approximate condensing and reboiling temperatures are respectively 123 F and 340 F. The average temperature is 230 F.

Then $t°_{RP} = 230 - \frac{(230 - 123)}{3} = 193$ F and $t°_{SP} = 230 + \frac{(340 - 230)}{3} = 267$ F. The preliminary information is listed on lines 1-4.

Lines 5 and 7

Calculate heavy key recoveries by Equations (7g) and (7h).

$$\mu° = (31.4)\frac{1.63}{1.87}(442 - 346.5) - (346.5)(1.63)(13 - 31.4) = 13{,}010$$

$$\rho° = (442 - 101.5)(13 - 31.4) - (13 - 4.6)(442 - 346.5)\frac{1.63}{1.87} + (346.5)$$

TABLE 2

LINE	iC_4	nC_4	iC_5	nC_5	C_6	C_7	C_8	C_9	ΣM/H	ΣLB/H	Temp. F	ΣMBTU/H
1	3.3	101.5	4.6	1.6	1.3	1.16	3.2	0.2	116.9	7,143	180	2,383
2	8.7	346.5	31.4	13.4	21.7	37.90	269.0	30.8	759.4	64,092	180	12,032
3	2.38	1.87	1.0	0.756	0.38	0.184	0.0855	0.0393	.....	....	....	.....
4	1.96	1.63	1.0	0.827	0.435	0.226	0.130	0.0739	.....	....	....	.....
5	1.19	0.99	0.606	0.501	0.264	0.137	0.079	0.0447	.....	....	....	.....
6	1.0	0.99	0.606	0.501	0.264	0.137	0.079	0.0447	.....	....	....	.....
7	0.288	0.366	0.685	0.905	1.80	3.72	8.0	17.4	.....	....	....	.....
8	0.288	0.366	0.685	0.905	1	1	1	1	.....	....	....	.....
9	4.86	250.0	27.6	13.75	9.55	7.37	26.35	1.66	341.1	....	....	.....
10	12.00	442.0	13.0	1.44	0	0	0	0	468.4	....	....	.....
3	2.80	2.05	1.0	0.755	0.312	0.131	0.059	0.0246	.....	....	....	.....
4	2.56	1.94	1.0	0.755	0.367	0.170	0.0745	0.034	.....	....	....	.....
5	1.325	0.987	0.508	0.383	0.186	0.0863	0.0378	0.0173	.....	....	....	.....
6	1	0.987	0.508	0.383	0.186	0.0863	0.0378	0.0173	.....	....	....	.....
7	0.193	0.263	0.540	0.715	1.73	4.12	9.15	21.9	.....	....	....	.....
8	0.193	0.263	0.540	0.715	1	1	1	1	.....	....	....	.....
9	2.87	157.0	12.6	6.62	6.55	4.85	13.89	0.75	205.1	13,356	133.5	2,255
10	12	442	13	2.64	0	0	0	0	469.6	27,447	....	.....
11	0	6	23	12.36	23	39.06	272.2	31	406.7	43,758	....	.....
12	11.57	497.5	21.0	7.66	5.25	3.69	10.69	0.55	557.9	33,640	168	10,980
13	14.85	599	28.2	9.24	3.72	1.18	1.52	0.03	657.7	38,692	133.5	12,080
14	14.85	599	28.2	9.24	2.15	0.29	0.17	.....	654	....	129.5	.....
15	14.85	599	28.2	9.24	0	0	0	0	651	38,077	129	11,803
16	8.7	503.5	46.7	20.0	23.3	42.75	282.89	31.55	959	89,388	168	15,850
17	6.57	503.5	46.7	20.0	23.3	42.75	282.89	31.55	957	....	169	.....
18	0	503.5	46.7	20.0	23.3	42.75	282.89	31.55	950.3	....	169	.....
19	1.36	1.05	0.537	0.417	0.194	0.0879	0.0371	0.0169	.....	....	....	.....
20	1.275	0.9865	0.504	0.380	0.180	0.082	0.0344	0.0158	.....	....	....	.....
21	0.164	0.222	0.468	0.62	1.53	3.80	8.60	20.5	.....	....	....	.....
22	0.248	0.34	0.716	0.95	2.38	5.64	13.70	33.0	.....	....	....	.....
23	.....	73	1.015	0.613	0.22	0.0893	0.0356	0.01605	.....	....	....	.....
24	.....	80	1.08	0.673	0.237	0.0957	0.0384	0.01719	.....	....	....	.....
25	0.33	0.515	2.52	19	.....	.....	.....	.....	.....	....	....	.....
26	0.22	0.336	1.65	12.4	.....	.....	.....	.....	.....	....	....	.....
27	.....	1.88	1	0.766	0.365	0.166	0.0732	0.0322	.....	....	....	.....
28	3.46	2.48	1	0.672	.....	.....	.....	.....	.....	....	....	.....
29	1	0.984	0.524	0.401	0.191	0.087	0.0383	0.0168	.....	....	....	.....
30	0.163	0.228	0.565	0.840	1	1	1	1	.....	....	....	.....
31	1.95	129.0	16.90	8.80	6.74	4.87	13.99	0.73	183.0	12,286	133	2,070
32	12	442	13	1.68	0	0	0	0	468.3	27,445	....	.....
33	0	6	23	13.72	23	39.06	272.2	31	406.7	43,760	....	.....
34	10.65	469.5	25.3	8.9	5.44	3.71	10.79	0.53	535	32,475	172	10,670
35	15.96	669.6	45.8	33.58	4.4	1.28	1.63	0.036	772.3	46,132	133	14,500
36	15.96	669.6	45.8	33.58	1.85	0.227	0.119	0.001	767.1	45,631	132	14,280
37	15.96	669.6	45.8	33.58	0.777	0.0402	0.0087	.....	764.1	....	131.5	.....
38	15.96	669.6	45.8	33.58	0	0	0	0	764.9	45,435	131.5	14,150
39	7.83	444	46.4	22.14	28.06	42.55	281.9	31.50	904.4	73,878	172	13,100
40	6.13	444	46.4	22.14	28.06	42.55	281.9	31.50	902.7	73,780	173	13,190
41	4.81	444	46.4	22.14	28.06	42.55	281.9	31.50	.....	....	173	.....
42	0	444	46.4	22.4	28.06	42.55	281.9	31.50	896.6	73,425	173	13,050
43	1.395	1.069	0.54	0.411	0.195	0.0903	0.0384	0.0172	.....	....	....	.....
44	1.27	0.975	0.501	0.380	0.183	0.0823	0.0360	0.0165	.....	....	....	.....
45	1.285	0.986	0.507	0.384	0.185	0.0833	0.0364	0.0167	.....	....	....	.....
46	0.152	0.206	0.433	0.575	1.42	3.52	7.96	19	.....	....	....	.....
47	0.240	0.330	0.695	0.921	2.31	5.46	13.3	32.0	.....	....	....	.....
48	0.242	0.332	0.70	0.928	2.33	5.51	13.4	32.2	.....	....	....	.....
49	.....	70.5	1.03	0.613	0.227	0.091	0.0378	0.017	.....	....	....	.....
50	.....	69.7	1.015	0.612	0.224	0.0899	0.0374	0.0168	.....	....	....	.....
51	.....	75.5	1.085	0.664	0.239	0.0982	0.0398	0.0175	.....	....	....	.....
52	0.319	0.497	2.33	12.9	.....	.....	.....	.....	.....	....	....	.....
53	0.316	0.493	2.31	12.8	.....	.....	.....	.....	.....	....	....	.....
54	0.20	0.308	1.43	7.93	.....	.....	.....	.....	.....	....	....	.....
55	.....	1.90	1	0.767	0.381	0.172	0.0737	0.033	.....	....	....	.....
56	3.53	2.49	1	0.662	.....	.....	.....	.....	.....	....	....	.....

$$(4.6)\ (1.63) - \frac{(31.4)\ (101.5)}{1.87} = -6{,}072$$

$$\xi^\circ = (13 - 4.6)\frac{101.5}{1.87} - (442 - 101.5)\ (4.6) = -1{,}112$$

$$U^\circ_{HK} = \frac{(6072 + [(6072)^2 - (4)\ (13{,}010)\ (-1{,}112)]^{1/2}}{(2)\ (13{,}010)} = 0.606$$

$$G^\circ_{HK} = \frac{(13 - 4.6) - (31.4)\ (0.606)}{(13 - 31.4)\ (0.606) - 4.6} = 0.685$$

Line 9. Given by Equation (7a). For example,

$$l^\circ_{nc\phi} = \frac{(101.5)\ (0.366) + (346.5)\ (0.366)\ (0.99)}{1 - (0.366)\ (0.99)} = 250$$

Line 10. Calculate non-specified distributed components by Equation (7e). For example,

$$d^\circ_{nc3} = \frac{(1.6) + (13.4)\ (0.501)}{1 - (0.905)\ (0.401)}\ (1 - 0.905) = 1.44$$

Zero-cycle constant zone temperatures are checked. If the original estimates are poor, the zero-cycle may be recalculated with relative recoveries at the new temperatures.

For the constant rectifying zone,

$$K^\circ_{HK,RP} = \frac{L^\circ_\phi}{(L^\circ_\phi + D^\circ)\ G^\circ_{HK}} = \frac{341}{(809)\ (0.685)} = 0.615 \text{ @ } 140 \text{ F.}$$

For the constant stripping zone,

$$K^\circ_{HK,SP} = \frac{U^\circ_{HK}\ (L^\circ_\phi + F_L)}{L^\circ_\phi + D^\circ - F_V} = \frac{1100 \times 0.606}{692} = 0.96 \text{ @ } 175 \text{ F.}$$

Because of the rather poor initial estimate of constant zone temperatures, lines 3-10 are repeated at the new temperatures.

Lines 13-15 furnish vapor compositions in the rectifying section. The dew-points are calculated for each of these streams. This gives respectively 133.5, 129.5 and 129 F for tray ϕ, $\phi + 1$ and the constant zone.

Lines 16-18 furnish liquid compositions in the stripping section. The bubble-points are calculated for each of these streams. This gives 168, 169 and 169 F. for tray Ψ, $\Psi + 1$ and the constant zone.

Lines 9-18. The weight and heat content of each stream shown on these lines is calculated, except for the streams on lines 14 and 17 that are used for temperature calculations only in this cycle. These physical properties are required for heat balances.

Corrected molal stream quantities at the constant zones and those associated with trays ϕ and Ψ are calculated by heat balances with the established feed-zone stream quantities. The first cycle tray factors at these points can then be evaluated.

It is not necessary to deal component-wise with the liquid streams above the feed zone or the vapor streams below the feed zone. The overall physical properties of these streams are established from the overall properties of the section product and the other stream in the section. For example, from the difference of total moles and weights shown on lines 10 and 13, $L^\circ_{\phi+1} = 188.1$ M/H or 11,245 LB/H. The average molecular weight of $L^\circ_{\phi+1} = 59.8$. Also $h^\circ_{\phi+1} = 172$ Btu/Lb. From line 13, $H^\circ_\phi = 12{,}080{,}000/38{,}692 = 312$ Btu/Lb.

A heat balance around tray ϕ gives $172\ L'_{\phi+1} + 2{,}383{,}000 + 10{,}980{,}000 = 2{,}255{,}000 + 312\ (L'_{\phi+1} + 27{,}447)$. From this equation $L'_{\phi+1} = 18{,}030$ Lb/H or $18{,}030/59.8 = 302$ M/H. Then $V'_\phi = 302 + 470 = 772$ M/H.

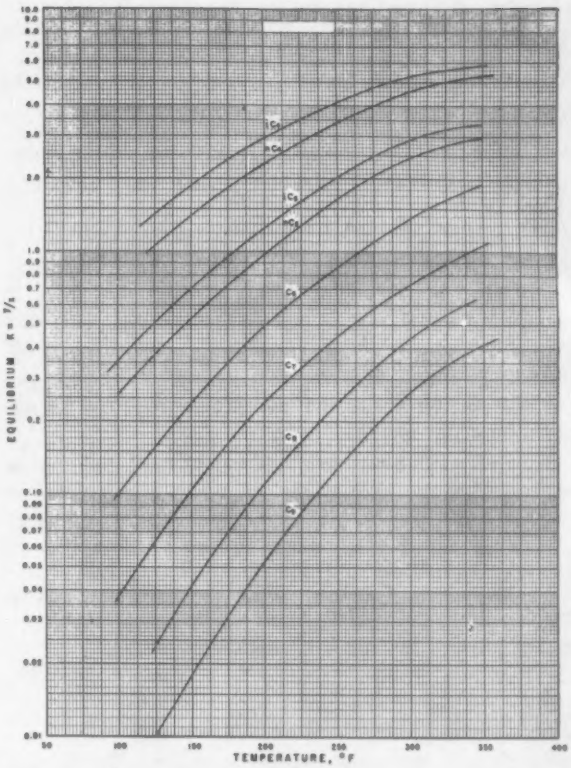

FIGURE 4—The equilibrium constants for the various components were obtained from this plot.

The heat balance equations should always be written to solve for the liquid streams in the rectifying section and the vapor streams in the stripping section. The larger stream is then obtained by material balance with the product.

Similar calculations give $L'_\psi = 914$ M/H. V'_{RP} is found to be approximately equal to V'_ϕ and L'_{SP} is approximately equal to L'_ψ.

The tray factors for trays ϕ and Ψ are established by these stream quantities and by the equilibrium values at temperatures of 133.5 F and 168 F, respectively. These factors are listed on lines 19 and 21.

The constant zone tray factors satisfy Equations (1) and (2). These equations may be modified as follows:

$$V'_{RP} = \frac{d'_C}{1 - \left(\frac{L}{VK_C}\right)'_{RP}} \qquad (1a)$$

$$L'_{SP} = \frac{b'_C}{1 - \left(\frac{VK_C}{L}\right)'_{SP}} \qquad (2a)$$

With the mole quantities of streams established by heat-balances, and with the previously calculated temperatures in the constant zones, it is quite easy to find the correct factors. For example, Equation (1a) will give

the quantity $V'_{RP} = 768$, when $\left(\frac{L}{VK_{HK}}\right)'_{RP}$ is taken as 0.716 with the remaining factors as $0.716/\alpha_c$, 129 F. And when $\left(\frac{VK_{HK}}{L}\right)'_{RP}$ is taken as 0.504 with the remaining factors as $0.504\ \alpha_c$, 169 F, Equation (2a) gives $L'_{RP} = 915$ M/H.

Generally, one tray factor in each constant zone is close to unity so that large changes in stream quantities result with small changes in tray factors. This tends to minimize trial and error in the calculation. The one-cycle constant zone factors are listed on lines 20 and 22 respectively.

These are typical of the calculations required for application of the method.

In the conversion step to weight and volume of streams from the mole quantities, where required to obtain enthalpies, full advantage of the tabular nature of the calculations should be taken. Particularly since quantities are often repeated down a column, it is best to proceed from column to column and convert an entire column of figures, rather than to deal with each stream individually.

It would be anticipated in view of the small change in internal reflux at the feed zone from the zero- to the one-cycle that additional calculations would contribute little or no change. As in this case, calculations beyond the one-cycle are generally not warranted. Relative recoveries for the two-cycle are almost identical to those for the one-cycle.

To balance the heat in streams 1, 31 and 34 with the top product as vapor, the external reflux required is 292 M/H.

Subcooled Liquid or Superheated Vapor Feed—The numerical operations for these feeds are very similar to those for the part vapor feed. They are listed in Tables

TABLE 3
Numerical Operations
For Subcooled Liquid Feed

Line	Distributed Components	Non-Distributed Components
(1) l_c	Preliminary	l_c — Preliminary
(2) $\alpha'_{c,RP}$	Preliminary	$\alpha'_{c,RP}$ — Preliminary
(3) $\alpha'_{c,e}$	Preliminary	$\alpha'_{c,e}$ — Preliminary
(4) $\alpha'_{c,RP}$	Preliminary	$\alpha'_{c,RP}$ — Preliminary
(5) $\left(\frac{L}{VK_c}\right)''_e$	Specified $\left(\frac{L}{VK_{HK}}\right)''_e/(3)$	$\left(\frac{L}{VK_c}\right)''_e$ — Specified $\left(\frac{L}{VK_{HK}}\right)''_e/(3)$
(6) $\left(\frac{VK_c}{L}\right)''_{e+1} < 1$	(4) × U''_{HK} by Eq. (10g)	$\left(\frac{VK_c}{L}\right)''_{e+1} \geq 1$ — (4) × U''_{HK} by Eq. (10g)
(7) U''_c	(6)	U''_c — Unity
(8) $\left(\frac{L}{VK_c}\right)''_{e+1} < 1$	(2) × G''_{HK} by Eq. (10h)	$\left(\frac{L}{VK_c}\right)''_{e+1} \geq 1$ — (2) × G''_{HK} by Eq. (10h)
(9) G''_c	(8)	G''_c — Unity
(10) $\bar{U}''_c$	By Eq. (10i)	$\bar{U}''_c$ — Unity
(11) $l''_{c,e}$	By Eq. (10b)	$l''_{c,e}$ — By Eq. (10b)
(12) d''_c	By Eq. (10e)	—
(13) b''_c	(1) — (12)	—
(14) $v''_{c,e}$	(11) + (12)	$v''_{c,e}$ — (11) + (1)
(15) $l''_{c,e}$	(5) × (14)	$l''_{c,e}$ — (5) × (14)
(16) $v''_{c,e}$	(15) — (13)	$v''_{c,e}$ — (15) — (13)
(17) $v''_{c,e}$	(11) + (12)	$v''_{c,e}$ — (11)/(8)
(18) $v''_{c,e+1}$	(17)	$v''_{c,e+1}$ — (17)/(8)
(19) $v''_{c,RP}$	(17)	$v''_{c,RP}$ — Zero
(20) $l''_{c,e}$	(11) + (1)	$l''_{c,e}$ — (16)/(6)
(21) $l''_{c,e+1}$	(20)	$l''_{c,e+1}$ — (20)/(6)
(22) $l''_{c,RP}$	(20)	$l''_{c,RP}$ — Zero
(23) $\left(\frac{VK_c}{L}\right)'_e$	From zero-cycle data—See instructions	$\left(\frac{VK_c}{L}\right)'_e$ — From zero-cycle data—See instructions
(24) $\left(\frac{VK_c}{L}\right)'_{e+1\,j>0}$		$\left(\frac{VK_c}{L}\right)'_{e+1\,j>0}$
(25) $\left(\frac{L}{VK_c}\right)'_e$		$\left(\frac{L}{VK_c}\right)'_e$
(26) $\left(\frac{L}{VK_c}\right)'_{e+1\,j>0}$		$\left(\frac{L}{VK_c}\right)'_{e+1\,j>0}$
(27) $\alpha'_{c,e}$		$\alpha'_{c,e}$
(28) $\left(\frac{VK_c}{L}\right)'_e$	$\left(\frac{L}{VK_{HK}}\right)''_e/(27)$	$\left(\frac{L}{VK_c}\right)'_e$ — $\left(\frac{L}{VK_{HK}}\right)''_e/(27)$
(29) $l'_{c,e+1\,j>0}$	(24)/1 — (24)	—
(30) $l'_{c,e}$	[1 + (29)] (23)	—
(31) $l'_{c,e+1\,j>0}$	(26)/1 — (26)	—
(32) $l'_{c,e}$	[1 + (31)] (25)	—
(33) u'_c	By Eq. (6)	—
(34) g'_c	By Eq. (5)	—
(35) U'_c	(33) × U''_{HK} by Eq. (10g)	U'_c — Unity
(36) G'_c	(34) × G''_{HK} by Eq. (10h)	G'_c — Unity
(37) $\bar{U}'_c$	By Eq. (10i)	$\bar{U}'_c$ — Unity
(38) $l'_{c,e}$	By Eq. (10b)	$l'_{c,e}$ — By Eq. (10b)
(39) d'_c	By Eq. (10e)	—
(40) b'_c	(1) — (39)	—
(41) $v'_{c,e}$	(38) + (39)	$v'_{c,e}$ — (38) + (1)
(42) $l'_{c,e}$	(28) × (41)	$l'_{c,e}$ — (28) × (41)
(43) $v'_{c,e}$	(42) — (40)	$v'_{c,e}$ — (42)
(44) $v'_{c,e}$	[1 + (31)] (39)	$v'_{c,e}$ — (38)/(25)
(45) $v'_{c,e+1}$	(44)	$v'_{c,e+1}$ — (44)/(26)
(46) $v'_{c,e+1}$	(44)	$v'_{c,e+1}$ — (45)/(26)
(47) $v'_{c,RP}$	(44)	$v'_{c,RP}$ — Zero
(48) $l'_{c,e}$	[1 + (29)] (40)	$l'_{c,e}$ — (43)/(23)
(49) $l'_{c,e+1}$	(48)	$l'_{c,e+1}$ — (48)/(24)
(50) $l'_{c,e+1}$	(48)	$l'_{c,e+1}$ — (49)/(24)
(51) $l'_{c,RP}$	(48)	$l'_{c,RP}$ — Zero
(52) $\left(\frac{VK_c}{L}\right)''_e$	From one-cycle data—See instructions	$\left(\frac{VK_c}{L}\right)''_e$ — From one-cycle data—See instructions
(53) $\left(\frac{VK_c}{L}\right)''_{e+1}$		$\left(\frac{VK_c}{L}\right)''_{e+1}$
(54) $\left(\frac{VK_c}{L}\right)''_{e+1\,j>1}$		$\left(\frac{VK_c}{L}\right)''_{e+1\,j>1}$
(55) $\left(\frac{L}{VK_c}\right)''_e$		$\left(\frac{L}{VK_c}\right)''_e$
(56) $\left(\frac{L}{VK_c}\right)''_{e+1}$		$\left(\frac{L}{VK_c}\right)''_{e+1}$
(57) $\left(\frac{L}{VK_c}\right)''_{e+1\,j>1}$		$\left(\frac{L}{VK_c}\right)''_{e+1\,j>1}$
(58) $\alpha''_{c,e}$		$\alpha''_{c,e}$
(59) $\left(\frac{L}{VK_c}\right)''_e$	$\left(\frac{L}{VK_{HK}}\right)''_e/(58)$	$\left(\frac{L}{VK_c}\right)''_e$ — $\left(\frac{L}{VK_{HK}}\right)''_e/(58)$
(60) $l''_{c,e+1\,j>1}$	(54)/1 — (54)	—
(61) $l''_{c,e+1}$	[1 + (60)] (53)	—
(62) $l''_{c,e}$	[1 + (61)] (52)	—
(63) $l''_{c,e+1\,j>1}$	(57)/1 — (57)	—
(64) $l''_{c,e+1}$	[1 + (63)] (56)	—
(65) $l''_{c,e}$	[1 + (64)] (55)	—
(66) u''_c	By Eq. (6)	—
(67) g''_c	By Eq. (5)	—

TABLE 4
Numerical Operations
For Superheated Vapor Feed

Line	Distributed Components	Non-Distributed Components
(1) l_c	Preliminary	l_c — Preliminary
(2) $\alpha'_{c,RP}$	Preliminary	$\alpha'_{c,RP}$ — Preliminary
(3) $\alpha'_{c,e}$	Preliminary	$\alpha'_{c,e}$ — Preliminary
(4) $\alpha'_{c,RP}$	Preliminary	$\alpha'_{c,RP}$ — Preliminary
(5) $\left(\frac{VK_c}{L}\right)''_e < 1$	(3) × Specified $\left(\frac{VK_{HK}}{L}\right)''_e$	$\left(\frac{VK_c}{L}\right)''_e > 1$ — (3) × Specified $\left(\frac{VK_{HK}}{L}\right)''_e$
(6) $\left(\frac{VK_c}{L}\right)''_{e+1\,j>0} < 1$	(4) × U''_{HK} by Eq. (11g)	$\left(\frac{VK_c}{L}\right)''_{e+1\,j>0} > 1$ — (4) × U''_{HK} by Eq. (11g)
(7) U''_c	(6)	U''_c — Unity
(8) $\left(\frac{L}{VK_c}\right)''_{e+1\,j>0} < 1$	(2) × G''_{HK} by Eq. (11h)	$\left(\frac{L}{VK_c}\right)''_{e+1\,j>0} > 1$ — (2) × G''_{HK} by Eq. (11h)
(9) G''_c	(8)	G''_c — Unity
(10) $\bar{G}''_c$	By Eq. (11i)	$\bar{G}''_c$ — Unity
(11) $l''_{c,e}$	By Eq. (11a)	$l''_{c,e}$ — By Eq. (11a)
(12) d''_c	By Eq. (11e)	—
(13) b''_c	(1) — (12)	—
(14) $v''_{c,e}$	(5) × (11)	$v''_{c,e}$ — (5) × (11)
(15) $l''_{c,e}$	(14) — (12)	$l''_{c,e}$ — (14) — (12)
(16) $v''_{c,e}$	(11) — (13)	$v''_{c,e}$ — (11) — (13)
(17) $v''_{c,e}$	(15) + (12)	$v''_{c,e}$ — (15)/(8)
(18) $v''_{c,e+1}$	(17)	$v''_{c,e+1}$ — (17)/(8)
(19) $v''_{c,RP}$	(17)	$v''_{c,RP}$ — Zero
(20) $l''_{c,e}$	(11)	$l''_{c,e}$ — (16)/(6)
(21) $l''_{c,e+1}$	(11)	$l''_{c,e+1}$ — (22)/(6)
(22) $l''_{c,RP}$	(11)	$l''_{c,RP}$ — Zero
(23) $\left(\frac{VK_c}{L}\right)'_e$	From zero-cycle data—See instructions	$\left(\frac{VK_c}{L}\right)'_e$ — From zero-cycle data—See instructions
(24) $\left(\frac{VK_c}{L}\right)'_{e+1\,j>0}$		$\left(\frac{VK_c}{L}\right)'_{e+1\,j>0}$
(25) $\left(\frac{L}{VK_c}\right)'_e$		$\left(\frac{L}{VK_c}\right)'_e$
(26) $\left(\frac{L}{VK_c}\right)'_{e+1\,j>0}$		$\left(\frac{L}{VK_c}\right)'_{e+1\,j>0}$
(27) $\alpha'_{c,e}$		$\alpha'_{c,e}$
(28) $\left(\frac{VK_c}{L}\right)'_e$	(27) × $\left(\frac{VK_{HK}}{L}\right)''_e$	$\left(\frac{VK_c}{L}\right)'_e$ — (27) × $\left(\frac{VK_{HK}}{L}\right)''_e$
(29) $l'_{c,e+1\,j>0}$	(24)/1 — (24)	—
(30) $l'_{c,e}$	[1 + (29)] (23)	—
(31) $l'_{c,e+1\,j>0}$	(26)/1 — (26)	—
(32) $l'_{c,e}$	[1 + (31)] (25)	—
(33) u'_c	By Eq. (6)	—
(34) g'_c	By Eq. (5)	—
(35) U'_c	(33) × U''_{HK} by Eq. (11g)	U'_c — Unity
(36) G'_c	(34) × G''_{HK} by Eq. (11h)	G'_c — Unity
(37) $\bar{G}'_c$	By Eq. (11i)	$\bar{G}'_c$ — Unity
(38) $l'_{c,e}$	By Eq. (11a)	$l'_{c,e}$ — By Eq. (11a)
(39) d'_c	By Eq. (11e)	—
(40) b'_c	(1) — (39)	—
(41) $v'_{c,e}$	(28) × (38)	$v'_{c,e}$ — (28) × (38)
(42) $l'_{c,e}$	(41) — (39)	$l'_{c,e}$ — (41)
(43) $v'_{c,e}$	(38) — (40)	$v'_{c,e}$ — (38)
(44) $v'_{c,e}$	[1 + (31)] (39)	$v'_{c,e}$ — (42)/(25)
(45) $v'_{c,e+1}$	(44)	$v'_{c,e+1}$ — (44)/(26)
(46) $v'_{c,e+1}$	(44)	$v'_{c,e+1}$ — (45)/(26)
(47) $v'_{c,RP}$	(44)	$v'_{c,RP}$ — Zero
(48) $l'_{c,e}$	[1 + (29)] (40)	$l'_{c,e}$ — (43)/(23)
(49) $l'_{c,e+1}$	(48)	$l'_{c,e+1}$ — (48/(24)
(50) $l'_{c,e+1}$	(48)	$l'_{c,e+1}$ — (49)/(24)
(51) $l'_{c,RP}$	(48)	$l'_{c,RP}$ — Zero
(52) $\left(\frac{VK_c}{L}\right)''_e$	From one-cycle data—See instructions	$\left(\frac{VK_c}{L}\right)''_e$ — From one-cycle data—See instructions
(53) $\left(\frac{VK_c}{L}\right)''_{e+1}$		$\left(\frac{VK_c}{L}\right)''_{e+1}$
(54) $\left(\frac{VK_c}{L}\right)''_{e+1\,j>1}$		$\left(\frac{VK_c}{L}\right)''_{e+1\,j>1}$
(55) $\left(\frac{L}{VK_c}\right)''_e$		$\left(\frac{L}{VK_c}\right)''_e$
(56) $\left(\frac{L}{VK_c}\right)''_{e+1}$		$\left(\frac{L}{VK_c}\right)''_{e+1}$
(57) $\left(\frac{L}{VK_c}\right)''_{e+1\,j>1}$		$\left(\frac{L}{VK_c}\right)''_{e+1\,j>1}$
(58) $\alpha''_{c,e}$		$\alpha''_{c,e}$
(59) $\left(\frac{VK_c}{L}\right)''_e$	(58) × $\left(\frac{VK_{HK}}{L}\right)''_e$	$\left(\frac{VK_c}{L}\right)''_e$ — (58) × $\left(\frac{VK_{HK}}{L}\right)''_e$
(60) $l''_{c,e+1\,j>1}$	(54)/1 — (54)	—
(61) $l''_{c,e+1}$	[1 + (60)] (53)	—
(62) $l''_{c,e}$	[1 + (61)] (52)	—
(63) $l''_{c,e+1\,j>1}$	(57)/1 — (57)	—
(64) $l''_{c,e+1}$	[1 + (63)] (56)	—
(65) $l''_{c,e}$	[1 + (64)] (55)	—
(66) u''_c	By Eq. (6)	—
(67) g''_c	By Eq. (5)	—

3 and 4. The key exception is that the feed temperature is not established before the calculations are closed. The specification of the heavy key flash tray factor allows this sort of operation. This specification readily follows from a prior calculation for the feed as part vapor. If no such calculation has been made, the estimate follows from the knowedge that $\left(\frac{L}{VK_{HK}}\right)_{\omega} > \frac{L}{VK_{HK\ BP}} > 1/\alpha^{\circ}_{LK,\,BP}$ $\left(\frac{VK_{HK}}{L}\right)_{\theta} > \left(\frac{VK_{HK}}{L}\right)_{BP} >$ unity. The lower the degree of subcooling or greater the degree of superheating, the larger are the flash tray values. Values double those indicated or larger are likely to apply. There is no real reason to labor this point since lines 2-15 may be repeated if the constant zone or flash tray temperature estimates are far astray, or if the specified flash tray factor is found unsatisfactory. For a subcooled liquid feed, the constant stripping zone temperature check-equation becomes $K^{\circ}_{HK,\,BP} = \frac{U^{\circ}_{HK}\,L^{\circ}}{L^{\circ} - B^{\circ}}$. And for a superheated vapor feed, the constant stripping zone check-equation becomes $K^{\circ}_{HK,\,BP} = \frac{U^{\circ}_{HK}\,L^{\circ}_{\theta}}{L^{\circ}_{\theta} - B^{\circ}}$. After the preliminary estimate, the temperature and the relative volatility values at the flash tray are established by a bubble-point or dew-point calculation. A bubble-point calculation for the liquid composition given on lines 15 and 42 of Table 2 establishes tray ω temperature. And a dew-point calculation for the vapor composition given on lines 14 and 41 of Table 3 establishes tray θ temperature.

As an example, the feed for the separation previously considered is now considered to be subcooled liquid, so that $\left(\frac{L}{VK_{HK}}\right)_{\omega} = 2.10$. The results are listed in Table 5. Based on the previous calculations, the quantities $\alpha^{\circ}_{c,\,RP}$, $\alpha^{\circ}_{c,\omega}$ and $\alpha^{\circ}_{c,\,BP}$ are taken at 140, 175 and 175 F, respectively.

Heat balances are made around tray θ, constant rectifying section, tray Ψ and the constant stripping section, at the end of the zero-cycle. None of the heat balances need involve the stream F. For example, to determine mole quantity L'_{ψ}, the equation $325\ V'_{\psi+1} + 14{,}545{,}000 = 12{,}800{,}000 + 175\ V'_{\psi+1} + (175)\ (43{,}810)$ applies. Then $V'_{\psi+1} = 39{,}400/60.1 = 655$ M/H. And $L'_{\psi} = 655 + 407 = 1062$ M/H.

The one-cycle relative recoveries are practically the same as the zero-cycle values. Observe that tray factors on lines 23 and 24 are almost identical, so that the one-cycle relative stripping recoveries are the relative volatilities.

The feed temperature obtained by heat balance around tray ω is 158 F, 11 F below the boiling point.

Corresponding to the feed-zone reflux of 125.4 M/H, given on line 38, the external reflux by heat balance is 177 M/H.

DISCUSSION

In evaluating the method it is important to observe that the distribution of components other than the keys

TABLE 5

LINE	iC4	nC4	iC5	nC5	C6	C7	C8	C9	ΣM/H	ΣLB/H	Temp. F	$\frac{\Sigma MBTU}{H}$
1	12	448	36	15	23	39.06	272.2	31	876.3	71,235	.....	.....
2	2.80	2.05	1.00	0.755	0.312	0.131	0.059	0.0246	.....	.....	....	.....
3	2.56	1.94	1.00	0.755	0.367	0.170	0.0745	0.034	.....	.....	....	.....
4	2.56	1.94	1.00	0.755	0.367	0.170	0.0745	0.034	.....	.....	....	.....
5	0.82	1.08	2.10	2.78	5.72	12.32	28.2	61.8	.....	.....	....	.....
6	1.29	0.99	0.51	0.385	0.187	0.0854	0.0374	0.0171	.....	.....	....	.....
7	1	0.99	0.51	0.385	0.187	0.0854	0.0374	0.0171	.....	.....	....	.....
8	0.149	0.204	0.419	0.555	1.31	3.11	6.92	16.6	.....	.....	....	.....
9	0.149	0.204	0.419	0.555	1	1	1	1	.....	.....	....	.....
10	1	0.9895	0.488	0.367	0.1762	0.0812	0.0346	0.0162	.....	.....	....	.....
11	2.05	114.5	8.94	3.70	4.93	3.45	9.75	0.51	147.83	9,612	133	1,720
12	12	442	13	3.15	0	0	0	0	470	27,457	....	.....
13	0	6	23	11.85	23	39.06	272.2	31	406	43,810	....	.....
14	14.05	556.6	21.9	6.86	4.93	3.45	9.75	0.51	617.95	37,073	162	12,015
15	11.5	602	46	19.1	28.2	42.6	282.79	31.54	1063.7	83,217	162	14,545
16	11.5	596	23	7.25	5.2	3.54	10.59	0.54	656.7	39,816	163	12,800
17	14.05	556.5	21.9	6.86	3.76	1.11	1.41	0.0307	605.6	35,728	133	11,046
14	14.05	556.5	21.9	6.86	2.87	0.36	0.204	.....	602.7	.....	....	.....
19	14.05	556.5	21.9	6.86	0	0	0	0	599.3	35,129	130	11,000
20	8.9	602	46	19.1	28.2	42.6	282.79	31.54	1061.1	82,766	163	14,480
21	6.90	602	46	19.1	28.2	42.6	282.79	31.54	609.3	.....	....	.....
22	0	602	46	19.1	28.2	42.6	282.79	31.54	1052.5	82,250	163	14,390
23	1.295	0.988	0.494	0.37	0.168	0.0753	0.032	0.0148	.....	.....	....	.....
24	1.30	0.990	0.495	0.372	0.169	0.0755	0.0322	0.01485	.....	.....	....	.....
25	0.137	0.1855	0.391	0.518	1.28	3.18	7.18	17.10	.....	.....	....	.....
26	0.198	0.272	0.565	0.755	1.92	4.54	11.05	26.60	.....	.....	....	.....
27	2.60	1.97	1.00	0.76	0.354	0.161	0.068	0.031	.....	.....	....	.....
28	0.805	1.065	2.10	2.76	5.92	13.05	31.0	68.0	.....	.....	....	.....
29	.....	98.8	0.978	0.589	0.202	0.0815	0.033	0.015	.....	.....	....	.....
30	.....	99	0.98	0.593	0.204	0.0818	0.0332	0.01505	.....	.....	....	.....
31	0.247	0.374	1.30	3.08	.....	.....	.....	.....	.....	.....	....	.....
32	0.171	0.255	0.90	2.11	.....	.....	.....	.....	.....	.....	....	.....
33	2.60	1.97	1.00	0.76	0.354	0.161	0.068	0.031	.....	.....	....	.....
34	3.24	2.32	1.0	0.697	.....	.....	.....	.....	.....	.....	....	.....
35	1	0.985	0.50	0.38	0.177	0.0805	0.034	0.0155	.....	.....	....	.....
36	0.1255	0.1755	0.407	0.583	1	1	1	1	.....	.....	....	.....
37	1	0.984	0.487	0.369	0.1705	0.0769	0.0322	0.01471	.....	.....	....	.....
38	1.435	93.4	8.90	4.11	4.73	3.26	9.06	0.463	125.4	8,252	133	1,480
39	12	442	13	2.94	0	0	0	0	470	27,443	....	.....
40	0	6	23	12.06	23	39.06	272.2	31	406	43,824	....	.....
41	13.44	535.4	21.9	7.05	4.73	3.26	9.06	0.463	595.3	35,695	162	11,580
42	10.8	570	46	19.40	28	42.5	281.0	31.40	1029	81,062	162	14,190
43	10.8	564	33	7.34	5	3.44	8.8	0.40	623	37,238	163	11,980

at minimum reflux is given with little effort. No assumptions are required.

The approximate methods generally assume that total reflux distribution applies at minimum reflux also. Such calculations apply estimated average relative volatilities in the well-known Fenske equation.[7] The combined accuracy of these assumptions is questionable.

The Underwood method allows analytical calculation of the product distribution within the accuracy of assumptions of effective average relative volatilities and constant molal overflow. However, considerable extra calculations are required to account for such distributing components as the nC_5 of the example.

As to the accuracy of the general assumptions of constant relative volatility, two typical approximate methods were applied to the part vapor feed example problem. The Underwood method gave 187 Mole/H of minimum reflux, with the average relative volatilities at the two constant composition zones. The Colburn method, with stream enthalpies accounted for to the extent possible, gave 235 Mole/H minimum external pumped reflux. The true value is 292 Mole/H. Outside of the gross errors involved, the important point to note is that the feed has an apparent "q" value much larger than that implied by the fraction of the feed vaporized. In this example the Colburn method with heat balances appear to have partly accounted for this effect. It should not be assumed that the Colburn method does not contain the assumption of constant molal overflow since the empirical relationships were developed from a number of examples in which constant molal overflow applied or was assumed to apply.

Not all problems converge to the accurate minimum reflux as quickly as the example problem. For example, a catalytic reformate debutanizer with a small amount of feed vaporized gave feed zone reflux rates of 798, 580 and 525 Moles/H in successive cycles. The lower value occurred for the two-cycle, a point at which the relative recoveries approached constant values. The Underwood method applied as before gave 502 Mole/H minimum reflux. The Colburn method applied with heat balances gave 506 M/H of external pumped reflux. The true minimum pumped reflux is 816 Mole/H. This type of separation is probably a more severe test for an empirical method because of small key quantities in the feed.

These are not extreme cases but rather typical industrial design problems. It is in problems such as these that the approximate methods fail to provide a reliable basis for cost estimates or the operating tower design.

There is little or no time-saving for the approximate methods over the proposed method. In view of the uncertainty of the results of the approximate methods and the very little information disclosed by them, the application of the proposed method is justified.

About the Author

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SYMBOLS USED

B = Bottom product, Mol/H
b = Component in bottom product, Mol/H
Cycle = Calculations between successive sets of relative recoveries
D = Overhead product, Mol/H
d = Component in overhead product, Mol/H
F = Feed, Mol/H
f = Component in feed, Mol/H
G = Rectifying recovery
$\overline{G}$ = Combined rectifying recovery
g = Relative rectifying recovery
I = Term in the general equation for g at minimum reflux
J = Term in the general equation for u at minimum reflux
K = Equilibrium constant y/x
L = Liquid stream, Mol/H
l = Component in liquid stream, Mol/H
q = Heat condition of feed. Heat required to vaporize one mol of feed divided by the latent heat.
t = Temperature, F.
U = Stripping recovery
$\overline{U}$ = Combined stripping recovery
u = Relative stripping recovery
V = Vapor stream, Mol/H
v = Component in vapor stream, Mol/H
x = Mol fraction of a component in a liquid stream
y = Mol fraction of a component in a vapor stream
μ, ρ, ζ = Terms in recovery equation for part vapor feed

Subscripts

HK = Heavy key component
LK = Light key component
C = General component
j = Index number
L = Liquid portion of feed
R = Entering rectifying section
RP = Located in rectifying pinch
S = Entering stripping section
SP = Located in stripping pinch
V = Vapor portion of feed
α = Relative volatility
θ = Flash tray for superheated vapor feed
ϕ = Feed tray for rectifying section
ψ = Feed tray for stripping section
ω = Flash tray for subcooled liquid feed
135 = Evaluated at temperature of 135 F.

Superscripts

o, ′, ″, ... prime marks refer to the number of the calculation cycle
i = Index number

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New System for Maintenance Control

Tolerable maintenance limits can be calculated so that you can avoid unadvised repairs, run a better balanced replacement program, and reduce the risk of breakdowns and high maintenance.

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IN THE FIRST ARTICLE of this series, two of the factors which are needed to determine limits of tolerable maintenance costs were discussed:

- The value of the unit to be maintained.
- Its operating conditions.

In this article the third factor, the maintenance budget, will be explained. Other factors covered are the method of calculating wear points for corrosion; the calculation of wear factors per unit and of average wear factors for the plant; the recording of maintenance costs taking into consideration the overhead of the maintenance department; the organization to immediately detect excessive maintenance costs; a reporting set-up and other details.

The Maintenance Budget

Maintenance budgets have a different purpose in different plants: they may be the upper limit of expenditures permitted by management, transgression of which will be permitted only in unforeseen emergencies. It may be an amount which the maintenance department is supposed *not* to reach, it may be an amount which *should* be spent to maintain the plant in good operating condition; it may be a fixed amount or a flexible one to take care of varying production. In any case, it is an important figure used by management together with other budgets to control the profit of the enterprise.

If we use it for calculating limits of tolerable maintenance in a particular plant, we assume that it is a reasonable budget. However, this does not prevent us from studying means and ways of adjusting it by installation of better maintenance methods. If no budget is available, an estimate of maintenance expenses for a certain period in advance will be substituted.

What expenses have to be included in the budget is a subject of great importance. Here we are faced with conflicting viewpoints which make the situation complicated. Maintenance, as such, is an expense which can be written off for tax purposes in the fiscal year when the expense occurred. Consequently, large repairs having an effect for several years are normally written off during the year when the expense was made. On the other hand, the cost accountant as well as the maintenance engineer have to spread such expenses over a number of months or years to obtain a reliable picture of maintenance costs per unit. The need for spreading such expenses becomes evident if we want to detect when a unit "goes over the limit."

Part 2

In addition, the maintenance engineer wants to have the complete costs per unit which comprise not only labor and material but also the overhead of the maintenance department, an amount which might be a substantial portion of the labor and material costs. Here we have to consider salaries of maintenance superintendents, plant engineers, their assistants, clerks in the maintenance office, rent, etc. for the office, designers, the stock room for tools and spare parts with attending personnel, expenses for perishable tools and all expenses connected with machine shops, salaries of foremen, etc. All these expenses disappear normally and rightly in the overhead of the company, but they are a substantial portion of the maintenance costs applicable to every unit to be maintained. Therefore, they should be considered as shown on a specimen history card (Figure 1).

The overhead of the maintenance department may be applied in the form of a percentage figure to maintenance labor or material or a total of the two. However, if we agree on the need of posting the overhead per unit, we are immediately compelled to be consistent. The amounts, including maintenance overhead posted on history cards, have to agree with the budget. In other words, in numerous plants we will have to establish maintenance budgets including the overhead outlined above.

Consequently, the new set-up has to fit the following reasoning: We want to be able to make decisions as to the advisability of replacements; consequently the data leading to such decisions should be complete. Since these data are:

- The record of maintenance costs posted on history cards, and
- Limits marked on the same cards which are calculated by means of the budget, it becomes important that the total of all maintenance costs posted equals the budget including maintenance overhead, assuming that actual

SMART ENTERPRISES INC. Equipment No. 568

Month 1957	Reference No.	Labor Costs $	Material Costs $	Subtotal $	Overhead Percent	Total Costs $	Remarks
Jan.	1067	10	125	135	60	216	
Feb.	1815	14	57	71	60	114	
March	1957	15	30	45	60	72	
April	1987	30	20	50	60	80	
May	2488	110	30	140	50	210	
June	2700	150	250	400	50	600	replaced
July							
Aug.							
Sept.							
Oct.							
Nov.							
Dec.							
					Limit	$ 300	

FIGURE 1—History Card.

expenses and budget are about the same.

How the budget ties in with the conception of limits is illustrated in Table 3.

This is the picture of what happens to one unit with regard to its physical condition and maintenance costs. The same picture, if applied to all units, shows in the lower section the budget. This budget takes care of new and old units irrespective of their physical condition. Consequently, neither the age nor the physical condition had to be considered in Table 2 (Part I of this series), a fact which may have appeared puzzling. The expression "useful" in "end of useful life" means "useful from the viewpoint of maintenance costs." The word "excessive" means that maintenance costs went over the limit. Maintenance costs can also be called excessive for other reasons, one example being if maintenance methods are inefficient.

Before a discussion on the calculation of limits, a word should be added about budgets for specific purposes. If there existed in a specific refinery one budget only covering maintenance of machines, equipment, buildings and grounds etc., units with widely diverging operating conditions, limits could not be calculated with a satisfactory degree of accuracy. Therefore, the example shown is based on the assumption that budgets have been established for groups of units with *similar* operating conditions, a practice which is followed anyway in numerous enterprises.

Calculating Wear Factors and Limits

Explanation of Table 4

Wear Factors. These are numbers which show the combined effect of wear (or degradation) upon a unit. We arrive at wear factors by multiplying the wear points selected as shown below. These wear points are taken from the Specimen Table of Wear Points (Table 2, Part 1 of this series).

Item No.	Wear Points
1	2.0
2	1.1
3	1.1
4	2.4
5	3.0
13	1.4

2.0 x 1.1 x 1.1 x 2.4 x 3.0 x 1.4 = Wear Factor 24.

The assumption of factor "2". We may decide to raise or lower the factor with which we multiply the monthly budget, permanently or temporarily, to speed up or to retard the replacement program. The advantage of this approach is that it permits management to tackle this touchy matter in an impartial manner since all units covered by the budget would be affected uniformly.

A curious discrepancy. The total of all limits is $4,725 while double the monthly budget amounts to $5,000. Why do the two amounts not agree? It is true, Table No. 4 could have been constructed so that the two amounts would be identical. This would look gratifying to the eye of the mathematically minded engineer but it would be deceiving. In actual practice, it would be a coincidence if the two amounts are identical, a theoretical possibility without importance. It is sufficient as a means of overall control of accuracy of wear points applied to individual units if the two amounts are not too far apart. They would be identical if dollar values of units as well as wear factors are equally distributed around the arithmetic mean.

Example:

Value of Unit $	Wear Factor	Limit $/Mth.
2,000	15	17.10
3,000	55	94.20
4,000	55	125.90
5,000	15	42.80
Total $14,000	140	280.00 = double monthly budget
	Average 35	

Budget: $1,680 per year or $140 per month
Investment: $14,000

$$\text{Limit} = \text{Value} \times \text{Wear Factor} \times \frac{\$140 \times 2}{35 \times \$14{,}000}$$

$$= \text{Value} \times \text{Wear Factor} \times 0.000572$$

Average Wear Factor and Wear Ratios. The average wear factor of 34 shown in Table 4 is a weighted average. Weighting is advisable whenever several identical or similar units with the same wear factor exist. To this end, the number of units in ques-

TABLE 3

Condition of Unit	New	Up to Average	Average	Over Average	End of Useful Life	Should Have Been Replaced
Maintenance Expense..	Small	Up to Average	Average	Over Average	LIMIT	Excessive

tion (eight in this case) are multiplied with the wear factor of the unit (for example, $25 \times 8 \equiv 200$ for items 3 — 10). The total of all wear factors (818) is divided by the number of units (24) and leads to the average wear factor 34.

This average wear factor is a measure of the average wear to which the group of units in question is subjected. The individual unit is subjected to more or less wear which may be expressed in form of a wear ratio. For example, the first item of Table 4 has a wear ratio of $65/34 = 1.9$. Wear ratios may be useful in determining the priority of preventive maintenance work.

Monthly Limits. One of the purposes of the new maintenance control method is to detect immediately when a unit "goes over the limit." Depending on the set-up for reporting and posting maintenance costs, this may be a daily, weekly or monthly affair. If the facilities are available and if the objects warrant it, it is certainly more efficient to find out as a daily routine that something has to be done about a certain unit than weeks later. Therefore, the tabulation of monthly limits should be considered as one of several possibilities.

Wear Points for Corrosion

A typical specimen compilation, Table 5, is based on data contained in the Corrosion Handbook. It applies to Acetic Acid, Material 1A to 1F.

The materials 1A to 1F are the following:

1A—Commercially pure aluminum. Not more than 1 percent total impurities, mainly iron and silicon.

1B—High purity aluminum, containing up to 99.85 percent Al.

1C—Al-Mn alloy, containing 1.2 percent Mn.

1D—Duraluminum-type alloy; containing 4.0 percent Cu, 0.5 percent Mn, and 0.5 percent Mg.

1E—Al-Mg silicide alloy; containing 0.7 percent Si, 1.3 percent Mg, and 0.25 percent Cr.

1F—Al-Si alloys, containing 5 to 12 percent Si.

These materials have Class A resistance at temperatures up to 85 F. This Class A is defined on page 748 (footnote) of the Corrosion Handbook of 1948 as follows: "Materials conforming to Class A will, in general, be those which corrode at a rate no greater than 0.005 ipy." In Table 5 this is called "Small Wear." If we assume a standard thickness of material of 0.1 inch, 0.005 ipy becomes 5 percent or 1.05 wear points. In our example, 1.05 is the upper limit for 85 F at a concentration of 99.9 percent. For lower concentrations, corresponding fractions of 1.05 have been assumed.

The materials 1A through 1F have Class B resistance at temperatures up to 160 F. The corresponding definition reads as follows in the Corrosion Handbook: "Materials conforming to Class B will, in many cases, be those which corrode at rates between 0.005 ipy and 0.05 ipy." This is called "Medium Wear" in Table 5. The calculation of wear points for this temperature range is based on the same considerations. The choice of the standard thickness of material depends upon circumstances.

Corrosion above 0.05 ipy would be called "Severe Wear." This condition would exist for Acetic Acid at temperatures up to boiling point. However, for this condition the materials 1A through 1F are not recommended.

Control Graph. The reliability of wear points as well as of wear factors may be checked by means of a Control Graph as per specimen. This graph is based on the assumption that normally there should exist a relation between operating conditions as expressed by wear factors and intervals between inspections and overhauls. A unit with wear factor 60 may require an overhaul every six months. Consequently, a unit subject to half the wear (wear factor 30) should require an overhaul once a year only. Similar considerations apply to intervals between inspections. It stands to reason that the usefulness of such a graph depends upon clear definitions of overhauls and inspections.

It is advisable to draw up the Control Graph as soon as feasible while setting wear points for operating conditions. Its farthest point to the right is easy to determine since the unit with the greatest wear and corresponding intervals of overhauls should be known. Then it may be extended to the left without difficulty.

Handling Deferred Costs. It is important to spread large repair costs over as many months or years as the effect of such repairs may be expected to last. (In actual practice, this period is normally reduced if the amounts to be posted get too small, relative to the work involved and/or the accuracy gained.) The principle of the procedure is shown on the Figure 3. It is worth mentioning that the notations on this form are independent of the fiscal year of your company.

Only the "amount charged" is

TABLE 4
Calculation of Limits

ITEM	No. of Units	Value of Unit $	Amount Col. 2 x Col. 3 $	Wear Factor	Limit per Unit $/Month	Total Limits Col. 2 x Col. 6 $/Month
Col 1	2	3	4	5	6	7
1	1	10,500	10,500	65	200	200
2	1	19,000	19,000	17	95	95
3-10	8	28,125	225,000	25 (200)	207	1,656
11	1	35,000	35,000	49	503	503
12	1	900	900	32	8	8
13	1	15,500	15,500	44	200	200
14-21	8	19,750	158,000	39 (312)	226	1,808
22	1	1,200	1,200	58	20	20
23	1	12,500	12,500	12	44	44
24	1	22,400	22,400	29	191	191
Total 24	24		500,000	(818)		4,725
			Average	34		

Assumptions: Budget $30,000/year or $2,500/month
Investment $500,000
Limits shall be reached when monthly maintenance costs reach double the average, therefore,

$$\text{Limit} = \text{Value} \times \frac{\text{Wear Factor}}{\text{Average Wear Factor}} \times \frac{\text{double monthly budget}}{\text{Investment}}$$

$$= \text{Value} \times \text{Wear Factor} \times 0.000294$$

TABLE 5

Concentration Percent by Weight	Temp. Up to F	Item No.	SMALL WEAR	Temp. Up to F	Item No.	MEDIUM WEAR
Up to 10	85	A1-1	1.00	160	A1-2	1.05
10 to 20	85	A2-1	1.01	160	A2-2	1.10
20 to 50	85	A3-1	1.03	160	A3-2	1.30
50 to 80	85	A4-1	1.04	160	A4-2	1.40
80 to 99.9	85	A5-1	1.05	160	A5-2	1.50

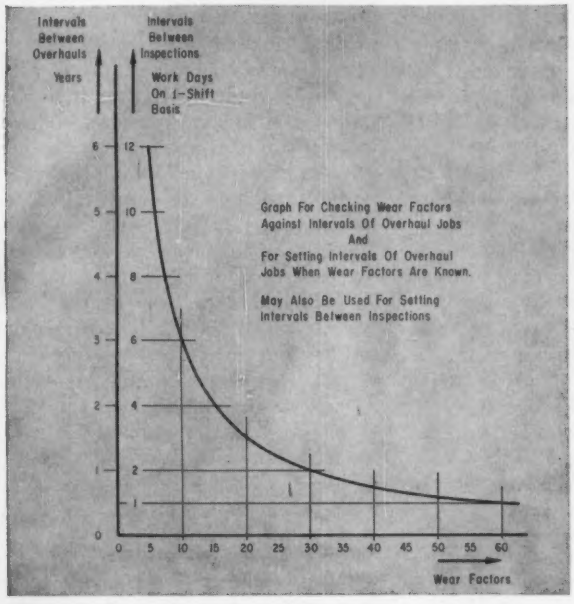
Intervals Between Overhauls Years
Intervals Between Inspections Work Days On 1-Shift Basis
Graph For Checking Wear Factors Against Intervals Of Overhaul Jobs And For Setting Intervals Of Overhaul Jobs When Wear Factors Are Known.
May Also Be Used For Setting Intervals Between Inspections
Wear Factors

FIGURE 2—Control Graph.

SMART ENTERPRISES INC.

DEFERRED COSTS

Reference No. 1099 Equipment No. 2058

Labor $ 45 Mat. $ 225 O.H. 60 Percent Months ..10.

Month 1956	Amount charged $	Balance $	Month	Amount charged $	Balance $
Oct.	43	389			
Nov.	43	346			
	etc.				

FIGURE 3—Form indicates principle of deferred costs procedure.

transferred to the History Card. However, it is good business to keep a record of the balances not yet absorbed. To this end, a summary of such balances may be kept by copying entries on Deferred Costs forms to a summary sheet.

Reporting Set-up. Depending upon the method used for posting, the fact that a unit "went over the limit" may be detected either by a posting clerk or a machine for punched cards or tape. This makes the operation of detecting excessive maintenance costs a practically automatic affair. The fact will be reported to the maintenance engineer who will investigate whether the unit is permanently over the limit or not. Perhaps the last repair had to be done with unsuitable spare parts or he finds that a new, better material became available to replace a worn-out part.

If he decides that the unit is permanently over the limit, he will report this fact to the executives who are looking after replacements. They may decide to buy a replacement or to postpone the purchase. In the latter case, a certain avoidable loss of money may be expected. If many units of this kind are not replaced, the maintenance budget may have to be raised or the quality of maintenance work would go down.

Before deciding on any larger repair, the maintenance engineer would be well advised to check the History Card to find out whether the repair job would bring the unit over the limit. If so, he may try to avoid that expense. With the new method it is feasible to replace in a systematic manner the units which may go over the limit early. This may be done by lowering all limits to a certain degree.

It may be advisable to make monthly reports to inform management about the situation. Figure 4 indicates a form that may be used.

This method of determining tolerable maintenance costs does not eliminate the judgment of maintenance personnel. On the contrary, its installation and operation requires it. However, it leads to a better utilization of their talent.

In addition it should help:

- To save money by avoiding unadvised repairs,
- to utilize capital investment to better advantage by keeping certain units in operation longer,
- to run a better balanced replacement program,
- to make quicker adjustments of budgets,
- to set schedules of inspections and overhauls even for units never before operated and thus reduce the risk of breakdowns and maintenance costs,
- to relieve the plant engineer of a great amount of clerical work and to give him a strong backing for recommendations of replacement,
- to make management decisions regarding replacements easier,
- to make history cards a tool of modern management ##

Number of Units	Percent of Total	Condition of Units	Monthly Maintenance Costs Dollars per Month	Percent of Total	Average Cost per Unit Dollars per Month
276.....	33	Obsolete	37,300	45	135
559.....	67	Good	46,033	55	82
835.....	100	Mixed	83,333	100	100

Note: The expression "obsolete" is used to indicate units which went permanently over the limit.

FIGURE 4—This method informs management of maintenance budget situation.

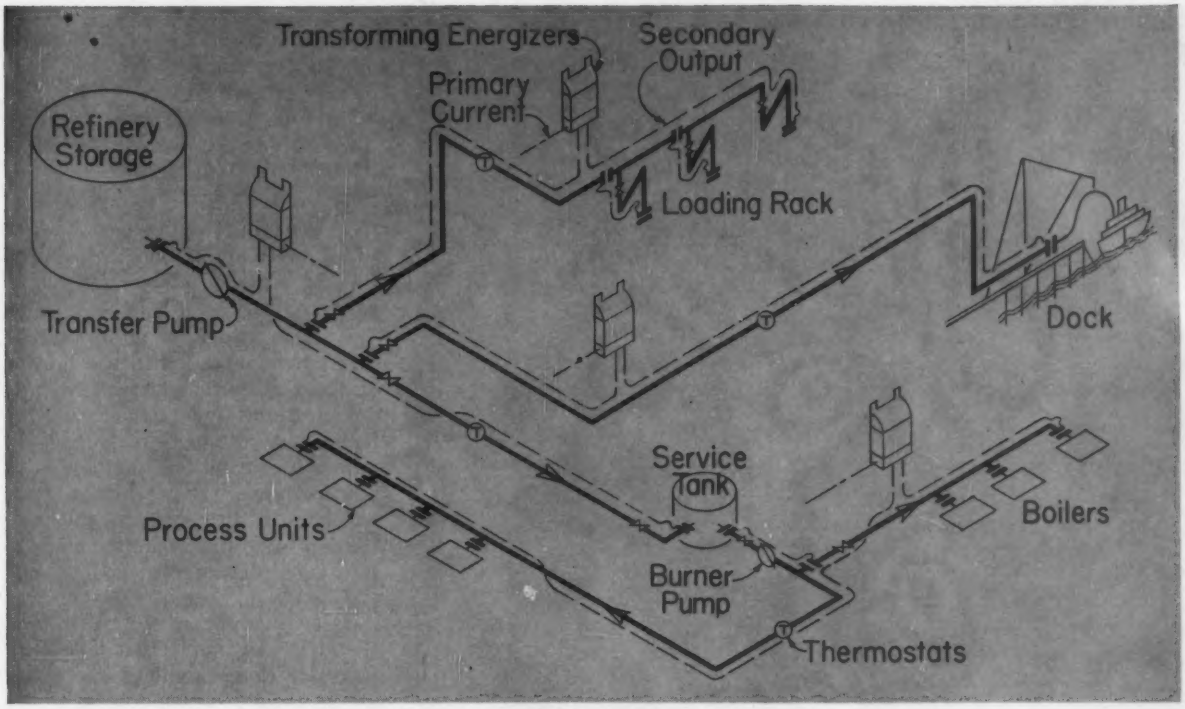

FIGURE 1—Impedence heating system eliminates cumbersome steam lines and accessories.

This new method for maintaining constant temperature in refinery piping systems will . . .

Eliminate Steam Tracer Lines

H. S. Bell
Frederick Snare Corporation
New York City

HOT OIL MEANS different things to different divisions of the petroleum industry. For instance it may mean bootleg oil to the producer but to the refiner the term means the headaches involved in the storage and transmission of products that must be handled at elevated temperatures. Such products that are common to many if not all refiners embrace heavy fuels, asphalts, still bottoms, paraffin wax and some lube oils.

A new method of applying electrical energy for maintaining a constant temperature in hot oil transmission lines has been developed. This method has been successfully used over the past few years by utilities and process industries. A discussion of the conventional and the electrical methods is presented herein.

The problem of heating in storage is outside of the scope of this article. It is assumed that the oil in the tank which is to be moved is at a satisfactory temperature insofar as viscosity and stability are concerned. The refiner is interested in the transfer, use and out loading of this oil.

The problem of transferring products of high viscosity involves the maintenance of sufficient temperature throughout the system to maintain viscosity within pumping limits. Friction loss through the pipe is a corrollary thereto.

The determination of line size is relatively simple using accepted formulae of hydraulic flow. But a frozen line presents complications. To thaw it out requires application of excessive heat and the question of heat sensitivity or stability of the product enters. Local overheating or density of heat flow may cause changes in the fluid. Many heavy fuel oils sludge and deposit carbon at excessively high temperatures. Lube oils may lose color and waxes polymerize.

To maintain flow temperatures and avoid any possibility of overheating close temperature control is necessary. Enough heat should be applied to just, and *just,* balance the loss from radiation. The product may then be maintained within very close limits at the temperature where it enters the line to the point of delivery.

In the early days of oil refining steam tracing the pipe line was the only method of meeting the stated problem. Some old timers may remember the attempt to place a steam line within a larger pipe conveying the oil. Mechanical difficulties quickly developed. Unequal expansion pre-

Eliminate Steam Tracer Lines . . .

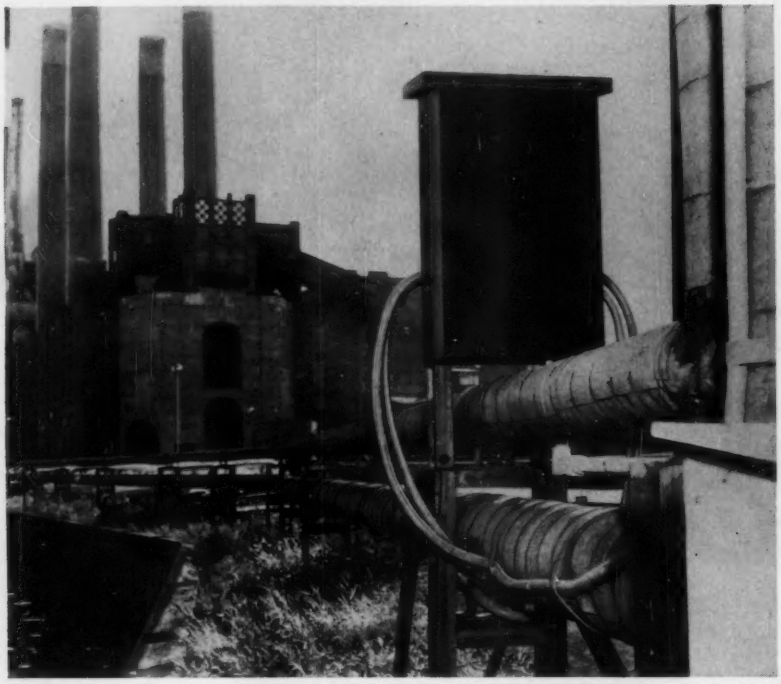

FIGURE 2—Energizers control each section of pipe. Note single cable strapped to outside of insulation along the pipe.

sented one and the internal line was brought out through stuffing boxes at intervals, expansion bends and traps were inserted and the steam line reintroduced. High costs of installation and maintenance were inevitable, leading to steam tracer lines outside of the oil conduit but wrapped integrally within the insulation jacket. But the steam tracer line or lines have to be withdrawn and trapped at intervals because of unequal expansion. At such points break down of the insulation presents a problem.

Another solution has been to use jacketted or semi-jacketted pipe. If hot water is used as the heating medium close temperature control is possible but this type of installation is limited to points where very favorable conditions prevail and to short lines and relatively small areas.

Aside from the mechanical difficulties a brief look at the theoretical handicaps of steam tracing may be helpful. Let us assume that a heavy oil of Bunker C characteristics is to be transferred. A temperature of 140 F is desirable to keep the viscosity to a reasonable figure and this temperature is to be maintained in the line. A 1 inch steam tracer line is wrapped integrally with a 4 inch oil line. Exhaust steam is available at 15 psi, temperature 250 F. At point of entry the temperature of the steam is presumably above the temperature at which sludging of the fuel oil will occur. It should be noted that contact between the hot steam line and the relatively cooler oil line is minute with consequent high heat density and corrollary over heating at this point. As oil and steam flow together, although in separate lines, the latent heat as the steam condenses offsets the loss by radiation. But as the steam cools and condenses it is obvious that the transfer of heat to the oil decreases. Finally the condensate is trapped out and a fresh supply of steam is injected. Therefore in a long line there is a very uneven rate of transfer both circumferentially and along the length of the pipe.

With the above in mind let us look at the problem of the public utilities who have been burning heavy viscous liquid fuels for years. In the early days a typical installation embraced a storage tank of oil at desired temperature, pump, a steam traced fuel line to the header for the burners, burner takeoffs and a traced return line to storage. The return line was essential to the utilities. It permitted uninterrupted flow if one or more boilers were "cut out" of service. As a result the pump was handling 50 to 100 percent more oil than the consumption of the boilers. Hence more power used, extra cost of larger pipe lines and extra cost of return lines. And with all precautions there was always the chance of a freeze and shut down if something went wrong.

The difficulties led to certain relief measures such as an emergency switch to lighter oil and purging of the lines. But the bogey of a freeze up was always present.

A few years ago the utilities turned their attention to impedence heating of their oil burning system. As later described this system maintains full temperature throughout. Suppose a burner is shut off and the flow in its branch header stops. Let it stop! Maintain its temperature automatically by electric heat and be ready to start immediately without purging and without any overheating and sludging. Let the whole system shut down! Do not purge! Let the system remain at constant temperature ready for immediate resumption of service or let it freeze if a long period is contemplated. In a short time line and oil may be raised again to operating temperature without damage of overheating.

Apart from operating advantages note that the return lines from burner headers to storage are unnecessary and since the pump handles only the oil necessary for the burners, both pump and flow line diameter may be smaller. All steam lines, traps and condensate return lines are eliminated. Lower capital costs are obvious.

Hence, the advantages of electric, impedence heated systems for heavy oil have been recognized by eleven utility companies. Some 200 other systems have been installed for paraffine wax in food packaging, for coke oven pitch in the steel mills and for molasses and other sensitive liquids. Hundreds of oil burner installations are in use. It has been used at 850 F to maintain lead in a molten state and at 40 F to keep water from freezing in above ground lines at arctic temperatures of —60 F.

Too often the term electric heating brings to mind the radiant heating elements in toasters, broilers or other electric appliances. Glowing and cherry red! And a common misapprehension for a pipe line is a length of pipe circumferentially wound with a hot electrical conductor coil. Such a

system would get into the realm of gadgetry.

The modern method is the impression of low voltage alternating current characteristics on the wall of pipe, using the fluid conductor also as a current conductor. Equal increments of heat are thus spread on each square inch of heat loss surface of a pipe system to offset heat loss exactly. Circumferential temperature gradients are reduced to zero and longitudinal gradients almost to zero. An automatic ambient temperature is thus created throughout the length of fluid flow so that an entering temperature can be maintained within a very close differential under all conditions of flow, rate or stand-by of flow. It is apparent that heat densities are so low as to accommodate any temperature sensitivity and to eliminate sludging or coking. This kind of operation lends itself to simple thermostatic control so the temperature of the entire pipe system is automatically maintained for any length of time and length of pipe, be it five hundred feet or many miles—and with any complication introduced by branch lines.

This system therefore has two inherent characteristics which make it unique for fluid transmission at elevated temperatures. These are:

- It makes no difference whether fluid is flowing or not. Therefore a single pipe system is all that is required. The refiner's fear of dead ends becomes groundless.
- The entire pipe system will thaw itself out after a complete shutdown. Pipe and contents will raise from minimum ambient to maximum design temperature in a specified period of time.

The impedence method of heating does not follow Ohm's Law. If a direct current is passed through a pipe, the quantity of heat in watts is equal to the impressed volts times the ampere flow, or the square of the amperes times the resistance in ohms, as in Ohm's Law. Although a magnetic conductor becomes magnetized, no energy is expended because the magnetic flux is a constant value. However, if an alternating current is impressed on a magnetic conductor, the consequent reversal of magnetic flux causes induction which opposes the current flow. The induction may be stated in reactance ohms.

Two factors offer impedence to current flow, one being resistance and the other reactance. Grouped, they may be stated as ohms impedence, being equal to the square root of the square of the resistance plus the square of the reactance. When two conductors are paralleled, one being magnetic, additional heat values become available. The alternating magnetic flux induces eddy currents within the magnetic conductor. The reluctance of magnetic flux to reverse polarity induces hysteresis. Thus, the heat impressed on the pipe wall is drawn from three sources—resistance, eddy currents and hysteresis—all resulting from the current originally impressed on the magnetic conductor. Actually a maximum of only 25 percent of the heat developed is from resistance.

An arrangement of this system for a typical refinery problem is illustrated by Figure 1. Note the energizers spaced throughout the system, each energizer (Figure 2) applicable to a given section of the pipe. The energizers receive current from the primary electric circuit at the usual A.C. current characteristics of 50 or 60 cycles split the phases and transform the voltage to the figure desired, usually 12 to 24 volts, at 50 to 60 cycles per second.

One lead from the energizer is attached directly to the pipe which is to become the conductor. A return cable is installed from pipe to energizer. The pipe, being insulated thermally, has one of the cables strapped to the outside of the insulation as in Figure 2. The heated pipe is electrically isolated at points of equipment connections, hangers and anchors. Thermostats control the temperature of flow to within ±2 F. of any desired figure.

Oil refiners have apparently been reluctant to consider electrical heating of hot oil transfer lines. This seems a paradox when so many utilities and process industries are successfully operating with the same oils and fluids that the refiner must handle in quantities.

Their questions may, perhaps, be summarized:

- Will it cost more to operate than the conventional steam traced system?
- Is it not too delicate for refinery or terminal operations with consequent high maintenance costs?
- Is it safe in relation to fire and personnel risk?
- What are the limitations of distance, temperature, size of line and volume of flow?
- Are we not still thinking in terms of the conventional electrical resistance coil heater?
- Is not the capital cost too high for refinery work?

An analysis of these objections may be helpful.

Operational Costs — Will it cost more to operate than the conventional steam traced system?

It is quite difficult to analyze the cost of operation of a steam traced line. To the refiners the cost of steam is variable dependent upon various systems of accounting. There is, however, one common denominator and that is the cost per 1000 B.T.U., and that figure is the dominating factor. A refiner may say that bleed or exhaust steam costs are negligible. But are they? If he goes back to his steam generators certainly their output has a monetary value. The steam used in tracing a line certainly loses at least the contained latent heat. Thus, even if the drips are returned, some 80 to 85 percent of the B.T.U. in the steam have still been expended in line heat. This heat has to be made up somewhere and inevitably shows up in boiler room costs.

The steam traced lines entail further costs than for steam alone. Careful

About the Author

H. S. BELL was for several years with Socony Vacuum and Sinclair, then he formed H. S. Bell, Inc., Consulting and Designing Petroleum Engineers. During World War II, Bell undertook the administration of British interests in Italy for the U. S. State Department, and then served as petroleum Consultant for the Board of Economic Welfare. Bell is the author of two books and is presently doing sales promotion work and petroleum engineering for Frederick Snare Corp., New York.

Eliminate Steam Tracer Lines . . .

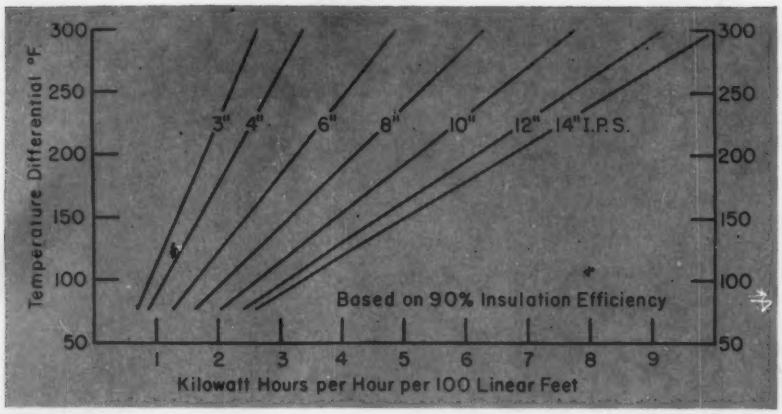

FIGURE 3—Power consumption of impedence system is surprisingly low.

inspection is necessary, particularly in cold weather, to guard against frozen traps. One prominent steel company with an extensive distribution system for heavy fuel and tar assigns a steam fitter to walk the lines constantly. Maintenance of lines is an appreciable item of cost. Unequal expansion of oil and tracer lines creates a maintenance problem with the insulation. The cost of purging or thawing out frozen lines is one item.

The cost of the electrical energy as applied to a line is surprisingly low. Since the system is designed to offset only the heat loss by radiation, the amount of current depends upon two factors only, the temperature differential between flowing oil and ambient atmosphere and the efficiency of the insulation selected. The size of the pipe enters into the calculation of total energy but heat density and the rate of heat transfer can be selected for the fluid characteristics involved regardless of pipe size.

Assuming 90 percent efficient insulation to be used, the chart (Figure 3) illustrates the power consumption per 100 feet of line for various temperature differentials between the conveyed liquid and the surrounding atmosphere.

Maintenance — Is it not too delicate for refinery or terminal operations with consequent high maintenance costs?

The oil industry has turned enthusiastically to automation in all types of process work in refineries and natural gasoline plants. Pipe line pumping stations operate unattended. Why not hot oil lines?

Perhaps the reliability of impedence heating might be best illustrated by the case of a major steel mill. An electrically heated coke oven tar line had been installed and operated for several years. Visitors wished to see the system. The management and the mechanical department had forgotten its exact location but investigation finally found it. It had been operating right along. No maintenance nor even inspection over a long period. This case is typical in the utility and steel industry although few go so far as to forget they have the installation.

Safety—Is it safe in relation to fire and personnel risk?

The use of single phase A. C. 50/60 cycle current at not to exceed 24 volts presents *no* risk to personnel.

The impedence system has been approved by the safety authorities of many large manufacturing plants for use in such locations as a gas compressor area in a refinery, above ground piping amidst naval stores or a naphthalene installation in a chemical plant. It is used on the properties of national fire insurance companies and on the properties for which they underwrite the fire risk. In areas where explosive gases may collect no electrical system should be considered.

Limitations—What are the limitations of distance, temperature, size of line and volume of flow?

Lines are sectionalized and hence there is no reason why it is not perfectly feasible to take Bunker C in New York and deliver it to Chicago at its original entry temperature within 2F. Oil lines up to five miles have been engineered awaiting pipe deliveries for installation.

The extremes of temperature may be illustrated by two examples of existing installations.

- Fluid, water at 40 F. Atmosphere —60 F.
- Fluid, molten lead at 850 F. Atmosphere 40 F.

Insofar as size of pipe is concerned electrically heated and controlled lines from ½ inch to 14 inch diameter are in use. There is no reason why lines of 24 inch or 30 inch diameter cannot be so heated.

Volume of flow is of course dependent upon pump pressures which in turn are dependent upon fluid characteristics and diameter and length of line. The above quoted ranges of temperatures and line sizes prove adaptability to any reasonable volume of flow.

Resistance Heating—Are we not still thinking in terms of the conventional electrical resistance coil heater?

Insofar as the refiners confusion between impedence heating and that by resistance coils is concerned the thinking should be directed to the modern methods of electrical heating.

Capital Costs—Is not the capital cost too high for refinery work?

A recent comparison of the cost of a steam traced line and an impedence heated line for a major steel company discloses that a line to convey 10,200 gallons per hour of number six fuel oil, 300 S.S.F. vis at 120 F., a distance of 3400 feet at 160 F. line temperature would cost $183,500 if steam traced and $138,500 if electrically heated.

In this case, which closely approximates most problems of transfer, the savings were made through the use of smaller pipe sizes, the elimination of the circulating line and the steam tracer lines, traps and condensate return system. Granting that in the case of delivery from tank to tank, no oil return line would be necessary, there would still be the necessity of cross connections for purging and the pipe and insulation costs would be higher on a footage basis. In almost any system steam tracing of the simplest type is higher in first cost. In the case of a jacketed or semi-jacketed steam heated line there can be no question of the lower capital cost of an electrically heated line.

ACKNOWLEDGMENT

The author wishes to express his appreciation to Fluid Systems, Inc., New Haven, Conn., for their aid and assistance in planning this article.

Set Conditions for Hydrogen Treating

THE HYDROGENATION process is getting more interest as a means of improving the stability and gum forming tendencies of cracked motor gasoline blend stocks. The work of Anderson, *et al*[1] and Young, *et al*,[14] on the selective hydrogenation of butadiene to butene at low pressures using low pressure type catalysts, such as supported nickel sulfide, suggested the application of low pressure hydrogenation as a means of selectively removing diolefins from cracked gasolines. The most recent papers on this subject by Casagrande, *et al*,[6] and Meerbott and Hinds[12] presented data on the selective hydrogenation of cracked gasolines over a nickel tungsten sulfide catalyst.

The work reported here was initiated on the postulation that conjugated diolefins were primarily responsible for certain of the engine deposits and for gasoline instability and that the rates of hydrogenation of the diolefins and mono-olefins present in gasoline stocks would be sufficiently different to permit hydrogenation of the diolefins preferentially. The objective of this work was to develop a commercial process which would remove these diolefins at conditions such that mono-olefin conversion was at a minimum at either a break-even or gain in leaded octane number. This report presents a summary of the process development work and certain kinetic interpretations of the data which led to the discovery of a commercial process possessing the necessary operating characteristics.[4]

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A method is proposed here for hydrogen treating a stock. The data were obtained by Hydrofining a thermally cracked naphtha.

SOME OF THE properties of products from selective hydrogenation can be correlated with the operating conditions of the process. Thus it is possible to predict the diene and olefin content and octane numbers of products within the range of a minimum of pilot plant runs, or to extrapolate outside this range with a high degree of confidence. Then it is easier to establish the conditions which compromise between removing objectional diolefins to achieve stability and retaining the mono-olefins for high octanes.

What Are the Variables? A commercial nickel tungsten sulfide catalyst was selected and all of the work reported was carried out using this catalyst. However, subsequent work[5] has demonstrated that the correlation technique developed can be used when other types of

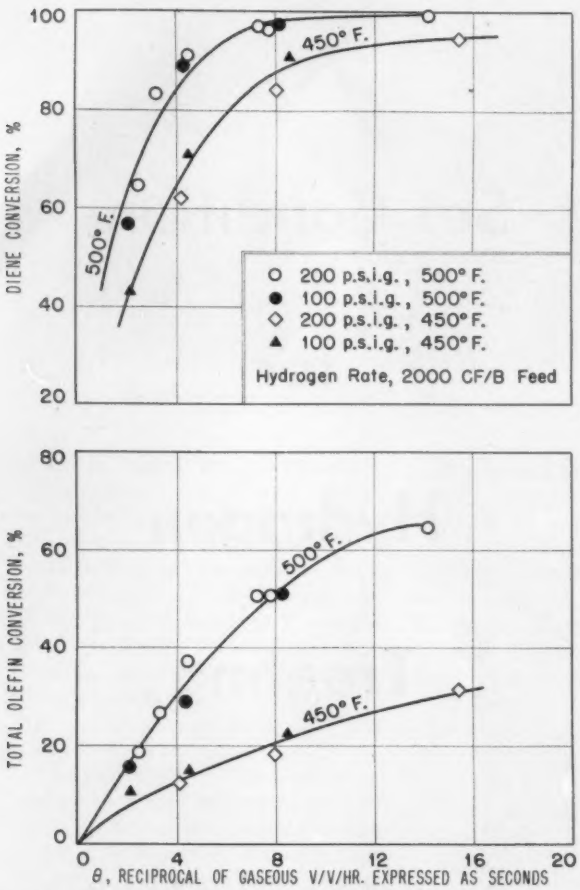

FIGURE 1—These data show that pressure has no effect on the rate of reaction except through its effect on contact time.

combination hydrogenation-desulfurization catalysts are employed.

All of the intial process variable studies carried out to define gross effects of operating variables were made using a mixed thermal naphtha containing 80 percent of material derived from thermal reforming of a West Texas virgin naphtha and 20 percent from thermal cracking of a typical refinery virgin residuum. Inspections of this feed along with the inspections on feeds which will be discussed later are presented in Table 1.

In the initial phase, runs were carried out using a constant nominal hydrogen to oil ratio of 2000 scf H_2/bbl. of feed while varying temperature from 400 to 500 F., pressure from 40 to 200 psig, and liquid hourly space velocity from 3 to 18. (The hydrogen content of the hydrogen rich gas averaged 72 mole percent, and, therefore, the total inlet gas rate was held at approximately 2800 scf/bbl.) The results for these and subsequent runs are reported in the appendix table; however, pertinent relations will be demonstrated graphically.

The effect of feed rate is shown in Figure 1, where the olefin conversions are plotted against a residence time expressed as the reciprocal of the cubic feet of total gaseous feed entering the reactor per hour at reactor conditions per volume of catalyst. (An assumption was made that both the hydrogen make-gas and vaporized hydrocarbon feed exhibited perfect gas behavior.)

As expected, the conversion of total unsaturates and dienes was found to increase with increasing temperature and pressure and with decreasing feed rate. The rate of diene hydrogenation was found to be appreciably greater than the rate of hydrogenation of the total unsaturates present. Furthermore, the data show that pressure per se has no effect on the rate of reaction except through its effect on contact time. This was found to be true for both total unsaturate and diene conversion, and made it possible to interchange feed rate and pressure at constant reactor temperature and hydrogen to oil ratio without influencing adversely the selectivity of the reaction.

The interdependence of pressure and feed rate can be used to advantage in reducing the investments required for a selective hydrogenation process employing an expensive catalyst. The catalyst cost can be held to a minimum by designing the plant installations for operation at maximum pressures consistent with operations above the dew point of the reaction mixture. The data also indicate that at comparable conditions of residence time and hydrogen to oil ratio, decreasing the reactor temperature results in an increase in the selectivity of the reaction.

The effect of hydrogen to oil ratio on this reaction was determined by runs held at constant temperature (500 F.), pressure (100 psig), and liquid feed rate (6 V/V/Hr.). The nominal hydrogen rate was varied from 100 to 4000 scf of H_2/bbl. of feed. The data obtained during this series of runs are plotted in Figure 2.

It will be seen that a variation in the hydrogen to oil ratio over the range studied brought about appreciable changes in the relative extent of hydrogenation reactions. This is emphasized by the decrease in total conversion that results as hydrogen to oil ratio is decreased, (where the residence time is being constantly increased). This would be interpreted to mean that the actual decrease in total conversion brought about by the variation of hydrogen partial pressure would have been even greater than that observed had the residence time remained constant.

A marked increase in the selectivity to diene conversion was observed as the hydrogen partial pressure was reduced, with a maximum point occurring at approximately 600 scf/bbl. of feed. In contrast to the maximum shown for diene conversion as a function of increasing hydrogen partial pressure, total unsaturate conversion is increasing more or less steadily over this same interval.

Kinetic Interpretation. The dependence of the hydrogenation reactions on the ratio of reactants, and appre-

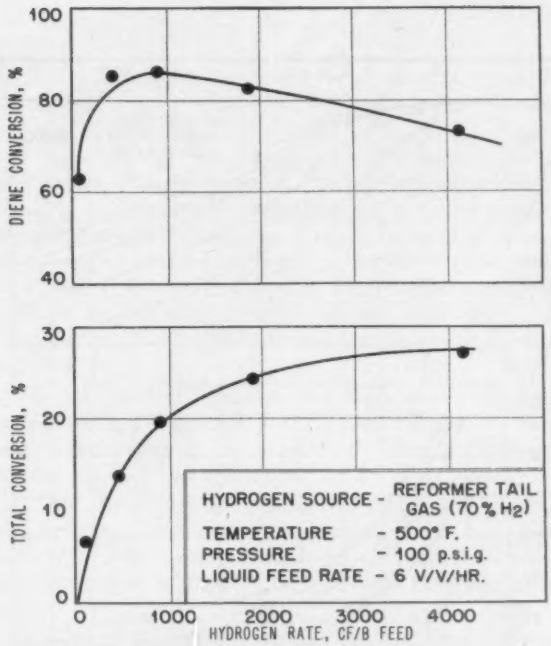

FIGURE 2—There is a point at which the selective conversion of dienes reaches a maximum even though the conversion of total unsaturates increases more or less steadily over this same interval.

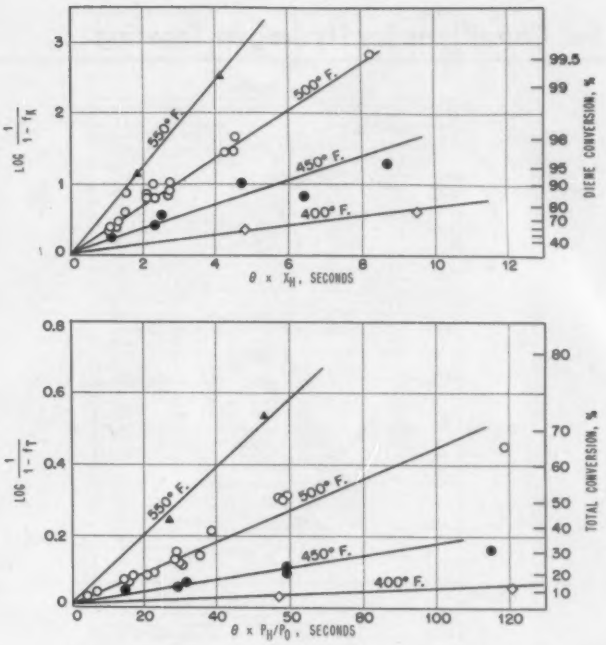

FIGURE 3—The actual data fit the proposed pseudo-kinetic equation very well.

ciable effect of temperature on the selectivity of the overall hydrogenation reaction suggested that the data obtained would lend themselves to interpretations and correlations based on concepts involving reaction kinetics. This system was found to be too complex to express in terms of conventional first or second order reaction rate equations. A convenient method of correlating experimental data of the type under discussion is to assume that the reaction system, even though a highly complex one, follows a pseudo first order relationship.[11] This is a reasonable assumption so long as only the contact time is varied at a constant temperature and hydrogen to oil ratio; however, the runs in which the hydrogen to oil ratio was varied did not correlate using either this pseudo first order approach or an integrated zero order reaction rate equation of the type:

$$f = (K)\ (\Theta)\frac{P_h}{P_o}$$

The definite dependence of the hydrogenation reactions on the concentration of hydrogen and/or olefin materials strongly suggested that the equations would have to include the concentration of one or both of the reactants. On this basis, it was possible to develop pseudo-reaction rate equations that fit the experimental data for this particular feed stock.

These equations are as follows:

$$\log\frac{1}{1-f_T} = K_T\Theta\frac{P_h}{P_o} \quad \ldots\ldots (1)$$

$$\log\frac{1}{1-f_K} = K_K\Theta X_h \quad \ldots\ldots (2)$$

where

K_T, K_K = pseudo reaction rate constants for total and diene conversions, respectively.

f_T = fraction of total unsaturates converted (based on bromine number reduction).

f_K = fraction of conjugated diolefins converted (based on reduction in ultra violet coefficient at 235 m/μ after correction for aromatic absorption).

P_h, P_o = initial partial pressure of hydrogen and total olefins, respectively.

X_h = mol fraction hydrogen at reactor inlet.

Θ = reciprocal of gaseous volume of reactants entering reactor, per volume of catalyst per hour (assume perfect gas behavior at reactor conditions).

The applicability of these equations to the data presented in Table 5 is shown in Figure 3 where it may be seen that an excellent correlation is attained. A further indication of the general utility of these equations is shown in Figure 4, which is a conventional plot of the Arrhenius equation. The fact that the data fall on a straight line lends confidence to the proposed correlations and will allow one to predict results for any selective hydrogenation operation within the range of temperatures covered by this investigation and lends confidence to extrapolation over narrow ranges. The reaction rate constants obtained at the various temperatures actually investigated, together with the ratio of K_K to K_T which are used as a measure of reaction selectivity, are presented in Table 2. A typical example of the use of the equations for predicting maximum selectivity for use in commercial plant operations is shown in Figure 5.

Optimum Hydrogen Rate. In connection with the use of low hydrogen to oil ratios for achieving high selectiv-

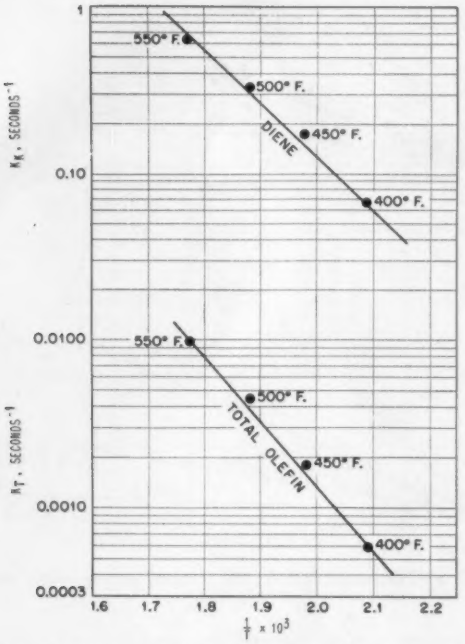

FIGURE 4—The nearness of the data to a straight line lends confidence to the proposed correlations.

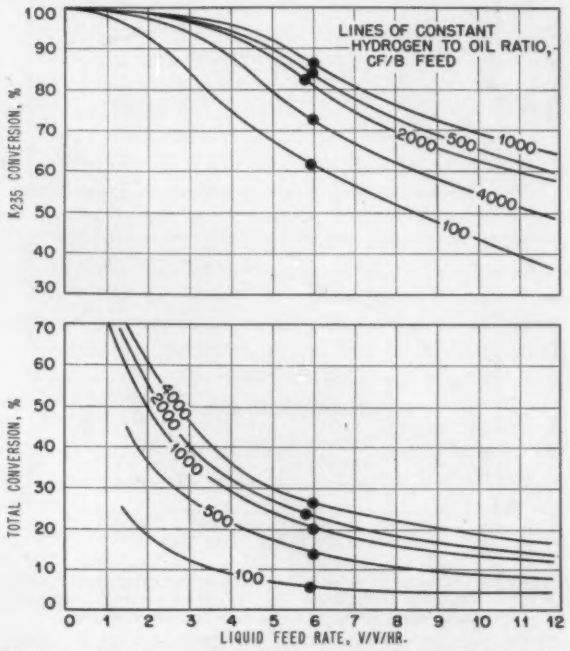

FIGURE 5—Here is an example of how the equations might be applied to information from a commercial plant operation.

ities, it should be pointed out that for a given feed rate, pressure, and temperature, the equations indicate that the extent of diene conversion can never be increased by increasing the hydrogen rate above 640 scf/bbl. of feed when a hydrogen rich stream (containing 72 percent of hydrogen) is employed as the source of hydrogen, or above 890 scf bbl. of feed when pure hydrogen is employed. These gas rates are equivalent to a molar gas-to-oil ratio equal to 1.0.

This observation may be substantiated by differentiated by differentiating the diene rate equation and setting the resulting derivative equal to zero. Thus, the residence time, Θ may be set equal to:

$$\frac{1}{(M)\,(C)\left(\frac{14.7}{P}\right)\left(\frac{T}{520}\right)} \quad \ldots\ldots(3)$$

where M = total pound molar feed rate per cubic foot of catalyst per second.
C = constant, 379 CF/lb. mol.
P = reactor pressure, psia.
T = absolute reactor temperature, ° R.

If reaction temperature and pressure are constant then $\Theta = 1/Ma$ where a is a contant.

Letting $M = M_1/X_1$, where M_1 is the lb.-molar feed rate of liquid naphtha per cubic foot of catalyst per second, and X_1 is the mol fraction liquid naphtha in the total feed entering the reactor, the diene rate equation (Equation 2) becomes

$$\log\frac{1}{1-f_K} = K_K \cdot \frac{X_h}{Ma} \quad \ldots\ldots(4)$$

$$= K_K \cdot \frac{X_1 X_h}{M_1 a} \quad \ldots\ldots(5)$$

With the assumption of a constant liquid feed rate, M_1 is a constant and letting $b = X_h X_g$ where X_g is the mol fraction of the gas used as hydrogen source and since $X_g = 1 - X_1$, then equation (5) becomes

$$\log\frac{1}{1-f_K} = K_K \cdot \frac{X_1 b X_g}{M_1 a} \quad \ldots\ldots(6)$$

$$= \frac{K_K b}{M_1 a} X_1\,(1-X_1) \quad \ldots\ldots(7)$$

Differentiating this equation, one obtains the following:

$$\frac{d\left(\log\frac{1}{1-f_K}\right)}{dX_1} = \frac{K_K b}{M_1 a}\,(1-2X_1) = 0 \quad \ldots\ldots(8)$$

Since $\frac{K_K b}{M_1 a}$ is constant, then $(1-2X_1) = 0$ and $X = \frac{1}{2}$. Also $X_g = \frac{1}{2}$ and therefore the gas-to-oil ratio, X_g/X_1, is equal to 1.0 for a maximum $\log\frac{1}{1-f_K}$. Further mathematical manipulation will show that the second derivative of $\log\frac{1}{1-f_K}$ with respect to X_1 is negative at $X_1 = \frac{1}{2}$; therefore, $\log\frac{1}{1-f_K}$ is a maximum there. Since $\log\frac{1}{1-f_K}$ varies with f_K (the greater the log function, the greater is f_K), f_K is at a maximum when

$X_g/X_1 = 1.0$. In other words, removal of conjugated compounds is maximum when the molar gas-to-oil ratio is equal to 1.0.

If the charge gas employed as the hydrogen source is not pure hydrogen, then the hydrogen-to-oil ratio at which f_K is a maximum is simply equal to b, the fraction of hydrogen in the charge gas. On the other hand it may be shown, from the rate equation for the saturation of total olefins (Equation 1), that the fraction converted increases continuously with the gas-to-oil ratio; this statement is further substantiated by the information in Figure 2.

The pseudo rate equations for both diene and total unsaturate hydrogenation further indicate that no conversion will occur in the absence of hydrogen. This was verified by an exploratory run.

It was also shown that the source of hydrogen gas had no effect on the reactions. A comparison of runs were made which hydroformer make-gas and cylinder hydrogen (from which traces of oxygen were removed) were used.

It will be noted that essentially the same reaction rate constants were obtained in each case, which further substantiates that the light hydrocarbons present in the hydroformer tail gas act merely as inert diluents. Therefore, hydrogen sources other than hydroformer make-gas, as for example coke oven gas, appear quite feasible, provided careful attention is given to the harmful effect that certain impurities contained therein may have on the particular catalyst being utilized.

Feed Stock Variable. One of the most complex variables in the hydrofinishing of motor gasolines is the source and composition of cracked motor gasoline charge stocks. It has long been recognized that naphthas produced by various types of cracking operations show marked differences in their composition, and it would not be surprising, therefore, that these naphthas would similarly show marked differences in their engine cleanliness quality and in their response to treatment for improvement with respect to this characteristic. Some work has been done to study the feed stock variable with respect to defining the response of typical cracked naphthas to hydrogenation. Pilot unit studies have been made using segregated thermal naphthas produced from the thermal cracking of (1) process gas oil (PGO) and (2) residuum. Data obtained on these two stocks together with that obtained on the thermal naphtha previously discussed (primarily from reforming operations) very definitely showed the importance of the feed stock variable. These three thermal naphthas had essentially the same boiling range, but their composition (Table 1) and response to hydrogenation were markedly different as shown in Table 3 for runs carried out at 500 F., 500 CF of hydrogen per barrel of feed, and the same reaction times.

The data obtained on the three naphthas indicated that the conversion of total olefins could be expressed by the same pseudo reaction rate equation developed for the mixed thermal naphtha. A tabulation of reaction rate constants, presented in Table 4, is a further indica-

TABLE 1
Feed Inspections

	Mixed Thermal Naphtha*	Naphtha From PGO Cracking	Naphtha From Residuum Cracking
°API	51.7	59.3	59.2
Sulfur, Weight Percent	0.108	0.170	0.50
Bromine, No., cg/gm	42.8	52.8	61.1
UVK_{325} (1/gm-cm)	1.98	2.80	2.29
Induction Period, Minutes	30	85	165
ASTM Gum, mg/100 ml	12.2	76.0	.....
Copper Dish Gum mg/100 ml	43.7	122	.....
Research Octane No.:			
+ 1 cc TEL	82.5	73.0	69.0
+ 2 cc TEL	86.0	76.5	73.7
ASTM Octane No.:			
+ 1 cc TEL	74.0	67.0	66.4
+ 2 cc TEL	75.0	70.0	67.0
ASTM Distillation:			
IBP, °F	168	174	164
FBP, °F	374	356	382
°F @ 10 Percent	210	198	192
30 Percent	234	216	211
50 Percent	258	238	238
70 Percent	280	266	274
90 Percent	317	309	323

* Contains 80 percent of material from thermal reforming of West Texas virgin naphtha and 20 percent from thermal cracking of virgin residuum.

TABLE 2
Psuedo Reaction Rate Constants for Hydrofining a Mixed Thermal Naphtha

Temperature, °F.	Pseudo Reaction Rate Constant, Sec^{-1}		Selectivity Factor K_K/K_T
	Diene (K_K)	Total (K_T)	
550	0.63	0.0096	66
500	0.33	0.0045	73
450	0.17	0.0018	94
400	0.067	0.0006	112

TABLE 3
Products Inspections[1]

Type of Thermal Naphtha	80% From Reforming 20% From Residuum Cracking[2]	PGO Cracking	Residuum Cracking
Conversion, Percent:			
Total	44	30.9	17.3
Diene	99	98.5	76.6
Product Inspections:			
Bromine No.	24.0	43.4	50.5
UVK_{325}	0.10	0.12	0.55
Lamp Sulfur	0.032	0.054	0.310
Research Octane No.:			
+ 1 cc TEL	....	72.0	....
+ 2 cc TEL	84.6	76.5	75.0
ASTM Octane No.:			
+ 1 cc TEL	....	67.0	66.5
+ 2 cc TEL	....	71.8	68.8
Induction Time, Minutes	....	660	105
ASTM Gum, mg/100 ml	....	1.0	4.0
Copper Dish Gum, mg/100 ml	....	1.7	33.1

[1] Hydrofining was carried out at 500° F, 500 SCF of H_2/Bbl. feed, and the same reaction time.
[2] Predicted values for conversion and inspection based on equations and correlations presented in this paper.

TABLE 4
Pseudo Reaction Rate Constants Total Unsaturates Hydrogenating

Type of Thermal Naphtha	K_T @ 500 F, Sec^{-1}
80% from Reforming and 20% from Residuum Cracking	0.0045
PGO Cracking	0.0030
Residuum Cracking	0.0019

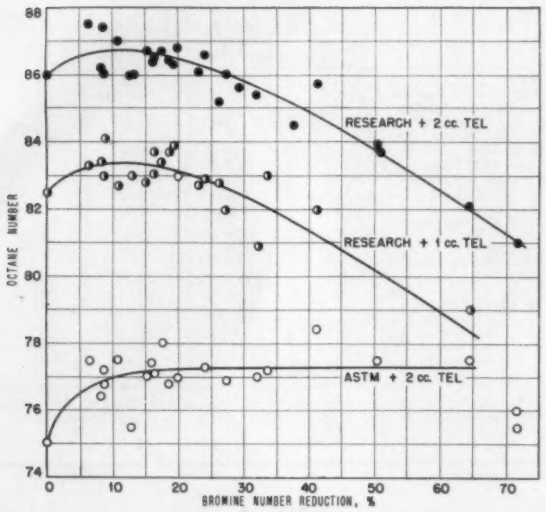

FIGURE 6—The bromine number of a naphtha may be reduced as much as 25 to 30 percent without reducing its octane numbers.

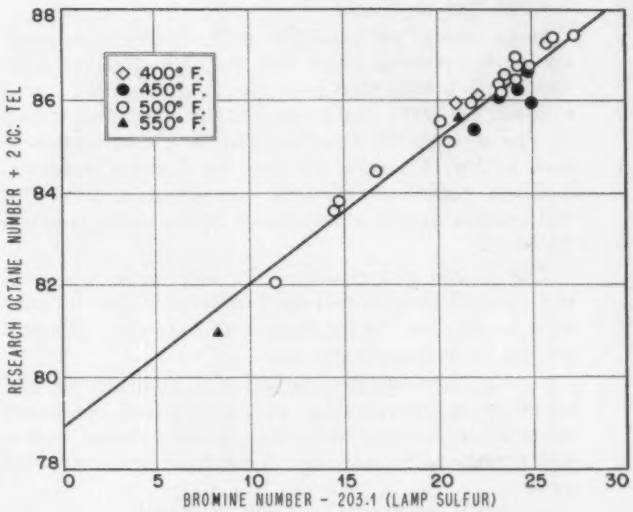

FIGURE 7—The leaded research octane numbers may be predicted from a correlation with bromine numbers and lamp sulfur analyses.

tion of the marked difference in the response of these feeds to hydrogenation, and in time, to the effect of feed stock composition on catalyst activity.

It was found further that the diene conversion for the naphtha produced in PGO cracking could be expressed in terms of the previously discussed reaction rate equation for dienes but that this equation apparently was not applicable for expressing the conversion of the dienes present in the residuum naphtha. It appeared that the dienes in the naphtha from residuum cracking were following a reaction rate mechanism more closely akin to that of the mono-olefins. This was confirmed by carrying out a number of additional runs on the thermal naphtha from residuum cracking data not reported) using both selective (low hydrogen rates) and non-selective conditions (high hydrogen rates). The variation in olifin saturation obtained with the three different thermal naphthas when they were hydrogenated under comparable conditions indicates either a marked difference in the type of olefin compounds present or a change in the equilibrium activity of the catalyst.

It is visualized that such a change in the catalyst activity might occur when stocks of abnormally high sulfur content are charged because of competing adsorption-desorption rates of the sulfur compounds particularly if the sulfur compounds are thiophenic or of a type

TABLE 5—Hydrofining of Mixed Thermal Naphtha[1] Over

Run No.	Feed	15	16	17	18	19	20	21	22	23	24	25
Reactor Temperature, °F	.....	502	500	501	450	498	500	500	550	454	452	450
Reactor Pressure, Psig	.....	200	200	200	200	100	100	200	200	200	100	200
Feed Rate, Liq. V/V/Hr	.....	6.0	8.9	11.9	6.0	6.0	3.0	5.9	5.9	3.0	3.0	11.6
Charge Gas Rate, SCF/B	.....	2962	3000	2925	2722	2341	2512	2754	2788	2797	2668	2599
Hydrogen Rate, SCF/B	.....	2261	2340	2260	1990	1690	1864	2141	2183	2107	1951	1870
Contact Time, Θ, sec	.....	7.5	4.6	3.6	8.0	4.4	8.3	7.4	7.0	15.6	8.5	4.2
Product Inspections:												
Bromine No., cg/gm	42.8	21.0	26.7	31.6	34.5	30.3	21.2	21.2	12.1	29.1	32.9	37.4
UVK_{235}(1/gm-cm)	1.98	0.16	0.27	0.40	0.39	0.29	0.13	0.16	0.11	0.18	0.27	0.81
Sulfur, Weight Percent	0.108	0.032	0.048	0.053	0.050	0.050	0.032	0.032	0.019	0.035	0.047	0.061
Research Octane No.:												
+ 1 cc TEL	82.5	.....	.....	82.8	83.9	.....	.....	.....	76.0	80.9	82.7	.....
+ 2 cc TEL	86.0	83.7	84.5	85.2	86.3	85.6	83.9	83.9	81.0	85.4	86.1	86.0
Motor Octane No.:												
+ 2 cc TEL	75.0	.....	.....	.....	.....	.....	77.5	77.5	75.5	77.0	77.4	.....
Induction Time, Minutes	30	945	760	>1080	>640	900	>1020	.....	695	525	270	345
Copper Dish Gum, mg/100 ml	43.7	12.8	12.1	4.8	7.9	4.6	3.6	5.7	8.1	10.2	11.9	8.3
ASTM Gum, mg/100 ml	12.2	4.8	1.6	4.0	1.8	3.2	2.6	4.8	0.8	2.8	5.0	0.6
K_T, sec^{-1}	.....	0.0052	0.0053	0.0047	0.0016	0.0051	0.0052	0.0053	0.0103	0.0014	0.0019	0.0019
K_K, sec^{-1}	.....	0.32	0.36	0.38	0.13	0.43	0.37	0.34	0.62	0.15	0.22	0.18
P^h/P^o	.....	7.9	8.6	7.8	7.4	6.7	7.0	7.7	7.5	7.5	7.0	7.1
$X_H \times 100$	.....	58.8	59.9	58.2	55.6	52.4	54.7	57.0	57.3	55.6	54.8	56.1
Conversion:												
Total, Percent	.....	50.9	37.7	26.2	19.4	29.2	50.5	50.5	71.7	32.0	23.1	12.6
Diene, Percent	.....	96.4	90.6	83.8	84.4	89.6	98.1	96.5	99.3	95.5	90.6	62.0

[1] Hydrogen source was Hydroformer make gas. Feed as charged to the pilot unit contained about 3 percent pentanes and pentylenes. Since the Hydroformer make gas also contained C_5 and lighter fractions which were absorbed in the hydrogenated product, the data presented for feed and product inspections are those obtained on laboratory depentanized materials.

that do not possess high rates of reaction for desulfurization. This could probably be evaluated by conducting hydrogen studies of sulfur compounds, but this was outside the scope of the present study. That the factor involved here is one of temporary loss in catalyst activity, or "equilibrium activity," is attested to by the fact that returning to one of the other feeds sees the activity of the catalyst restored to the level previously evidenced for that stock.

Although excessive mono-olefin saturation was required to remove essentially all the dienes from the residuum naphtha, the penalties for octane degradation were not pronounced as in the case of the other naphthas because of the higher sulfur removal.

Product Octanes. In the evaluation of any treating process, the quality of the finished product is obviously the main factor which controls the over-all utility of the process. In treating cracked naphthas to improve their engine cleanliness quality, the primary objective was the selective reduction or removal of those compounds believed responsible for poor quality. Economic considerations dictated that in the case of hydrogenation, the hydrogenated product should have the maximum octane number obtainable for a satisfactory degree of cleanliness. It was found that when conditions of high selectivity were used, as prescribed by the pseudo reaction rate equation, the resulting product of low diene concentration was produced at either a gain or break-even point in leaded research octane number. Octane data were obtained on all of the runs made and have been reported in the appendix table. These data are depicted graphically in Figure 6, and illustrate that a gain or break-even in the Research octane number at both the 1 and 2 cc TEL levels was obtained up to a bromine number reduction of about 25 to 30 percent. A gain in the ASTM + 2 cc TEL octane number was obtained over the entire range studied (0-72 percent bromine number reduction), whereas a gain or break-even at the 1 cc TEL level was obtained up to about 35 percent re-

How data were obtained . . .

The investigation was carried out in a small scale pilot unit which consisted of a jacketed reactor, and auxiliary vessels and metering devices. The pilot unit is of the same general type as the one used during the war to study the hydrogenation of catalytic naphthas and polymers and serves as a general purpose unit for any process study involving the passage of liquid and gas over a catalyst bed.[9]

Of course, the preferred method for evaluating the end effects of this process would be to express the quality of the hydrogenated naphthas produced as a direct function of their performance in automotive engines. However, this is impractical because no completely satisfactory analytical test is available for predicting engine cleanliness characteristics. Therefore, it was decided to evaluate the process by relating the operating conditions to the relative disappearance of conjugated compounds and total unsaturates upon hydrogenation.

The disappearance of conjugated compounds, which is referred to as diene conversion, was computed as the reduction, upon hydrogenation, in the ultra-violet coefficient at 235 millimicrons corrected for the absorption of aromatics at this wave length. A typical means of measuring this coefficient has been described by Wadley and Anderson.[12] This method of representing diene conversion affords no differentiation between the conjugated compounds as to class (such as acyclic and cyclic dienes, styrenes, indenes, etc.), but rather indicates the conversion of all types of conjugated compounds exclusive of aromatics.

The disappearance of total unsaturates was computed on the basis of decrease in the bromine number, upon hydrogenation; bromine number was determined under carefully controlled conditions to yield a reproducibility of ±1 percent on the bromine number. No differentiation between total unsaturate conversion and mono-olefin conversion were made although this could be calculated by assigning an average ultra-violet coefficient to the dienes.

Nickel Tungsten Sulfide Catalyst—Summarized Data

26	27	28	29	30	31	32	33	34	35	37	38	39	40	41	42	43
451	500	500	499	450	499	501	501	499	499	499	550	398	400	500	500	499
100	200	200	100	100	100	100	100	100	40	100	100	200	200	100	86	57
5.8	3.0	17.9	11.9	11.9	5.8	6.0	6.0	13.5	3.0	5.9	5.9	2.9	5.9	5.9	3.0	6.0
2691	2839	2575	2531	2731	2750	1302	951	516	2235	5533	3021	2435	2563	130	6150	1458
1965	2173	1809	1896	1983	1997	947	466	383	1566	4105	2161	1700	1872	96	4414	1073
4.4	14.2	2.6	2.1	2.1	4.1	6.5	9.1	4.7	3.1	2.4	3.5	18.0	9.0	15.1	3.5	3.8
36.3	15.2	34.8	35.9	38.2	32.5	34.3	36.9	39.0	35.3	31.1	25.1	37.3	39.2	40.0	28.4	39.1
0.63	0.10	0.77	0.80	1.17	0.42	0.34	0.37	0.90	0.37	0.60	0.26	0.54	0.90	0.80	0.37	0.65
0.056	0.020	0.056	0.052	0.070	0.044	0.050	0.062	0.064	0.051	0.045	0.025	0.080	0.085	0.063	0.048	0.056
82.8	79.0	83.7	83.7	82.7	82.9	83.0	83.0	84.1	83.4	82.0	82.0	83.0	83.4	83.3	83.0	83.0
86.7	82.1	86.4	86.4	87.0	86.6	86.8	86.5	87.4	86.7	86.0	85.7	86.0	86.2	87.5	85.5	86.0
77.0	77.5	76.8	77.4	77.5	77.3	77.0	77.1	76.8	78.0	76.9	78.4	75.5	76.4	77.5	77.2	77.2
540	> 480	345	300	165	600	645	> 480	285	980	525	> 480	210	170	318	> 780	480
5.1	8.2	20.7	10.5	.....	5.0	6.4	11.3	8.1	6.5	.....	16.1	.....	14.9	.....	63.9	40.9
0.8	2.8	3.2	2.0	.....	3.1	1.4	3.0	2.0	4.0	.....	5.6	.....	5.6	.....	30.0	25.2
0.0023	0.0038	0.0051	0.0052	0.0033	0.0042	0.0042	0.0041	0.0059	0.0032	0.0039	0.0085	0.0005	0.0007	0.0070	0.0033	0.0048
0.23	0.35	0.32	0.32	0.21	0.34	0.32	0.31	0.30	0.54	0.38	0.54	0.07	0.08	0.39	0.38	0.33
7.1	8.3	6.6	7.0	7.0	7.0	3.5	1.7	1.4	6.7	14.6	7.9	6.7	6.4	0.26	15.7	4.2
55.0	58.2	52.1	54.8	54.8	54.9	42.9	29.9	26.6	50.6	63.8	55.2	53.1	53.5	7.3	62.2	45.8
15.2	64.5	18.7	16.1	10.8	24.1	19.9	13.8	8.9	17.5	27.3	41.4	12.9	8.4	6.5	33.6	8.7
71.5	99.6	64.2	57.2	42.9	82.6	86.9	85.3	57.2	85.4	73.1	91.2	76.3	57.2	62.5	85.2	70.5

duction in bromine number. ASTM induction period,[3] ASTM gum[2] and copper dish gum[8] data were also obtained and indicate an increase in the stability of the products as a result of hydrogenation.

Periodic specific dispersion data obtained during the course of this investigation indicated that no aromatic hydrogenation took place during the runs. It was possible, therefore, to determine an equation relating leaded octane number to bromine number and sulfur content of the hydrogenated product without encountering the complications usually resulting from changes in aromatic and naphthene concentrations. The regression equation for predicting product Research octane number (with 2 cc added TEL) from runs involving the mixed thermal naphtha feed is as follows:

Res. O.N. + 2 cc TEL = 79.0 + 0.32 [Bromine No. — 203.1 (sulfur content)].

A graphic plot of this equation, shown in Figure 7 indicates that it fits the data within the accuracy and reproducibility of the laboratory octane test. Cole[7] has also presented a means of predicting octane number as a function of olefin saturation and sulfur removal.

Although this type of mathematical equation represents a satisfactory method of predicting octane numbers from product inspections, it has no real utility for predicting the octane number for runs not actually made unless some additional relationship is available for predicting the sulfur content of a product. We have been unable thus far to develop a simple and adequate rate relationship between sulfur reduction and the operating variables even though it is true that sulfur removal plays an important role in the selectivity of the reaction.[10,12]

In this work it was possible, however, to relate sulfur content to bromine number for the products of the mixed thermal naphthas. It will be recalled then that the bromine number for any selected set of run conditions can be predicted by the use of the pseudo reaction rate equations previously discussed.

This material originally was presented before the Atlantic City meeting of the American Chemical Society in September, 1956.

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How to Test Absorbers

Proposed AIChE Standard outlines procedure for testing the performance of absorbers

THESE MEN DID THE WORK

This standard was prepared by the following members of the A.I.Ch.E. Committee on Equipment Testing Procedures:

W. R. Marshall, University of Wisconsin, General Chairman

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Complete Text of Standards Starts on Page 189

TO CONDUCT performance tests on absorbers, AIChE has proposed a new standard testing procedure. This standard is part of the work being done on procedures for testing heat exchangers by the AIChE Committee on Equipment Test Procedures. It provides a standard means of comparing manufacturers' predicted performance.

Parts 5 through 7 are reproduced here in full. For a compete text of the other parts, see Page 189. AIChE section numbers are indicated at the end of each paragraph in parenthesis.

5. Test Procedure

Start-Up Procedure. The start-up procedure may vary depending upon the relationship between the absorber and the other process equipment. Start-up procedures for a test run should be the same as for the usual operating run. (5.1)

Approach to Steady State. The time required for a close approach to steady state varies with the degree of absorption and the recycling of gas and liquid streams to the absorber from other parts of the process. (5.2)

If the desired degree of absorption is low and only fresh solvent is continually introduced into the absorber steady state will be attained in a minimum time. (5.21)

If the degree of absorption is high and/or the solvent is recycled after stripping in a separate piece of equipment the time for the entire unit to come to steady state will be considerably longer. (5.22)

More complex processes with recycle streams from other steps introduced into the absorber may make the attainment of steady state so slow that consideration should be given to withholding the streams for duration of the tests. (5.23)

Recording Data. The observation of complete data should be started only when the unit is operating at steady state conditions. In the preliminary period samples of the streams entering and leaving the absorbers should be taken at time intervals such that both the gas and liquid holdup in the unit shall be replaced at least twice in the period. In general the liquid holdup will be controlling. (5.3)

Steady state can be assumed to prevail when five successive samples of

liquid and gas entering and leaving the absorber show a random distribution about a mean value consistent with the limits of accuracy of the sampling and analytical techniques. In general when the feed streams are known to be substantially constant, the greatest variation in approaching steady state will be in the amount of solute in the lean gas. It should be recognized that when the degree of absorption is high the approach to steady state in this lean gas will be slow and a small but consistent trend in the deviations are within the limits of accuracy of the analytical techniques. Statistical methods may be used to interpret the results of the measurements. (5.31)

Test Period. The test period may be of any predetermined duration but it should not be less than the time to replace both the gas and liquid holdup in the system five times. It is recommended that a heat and material balance be made on the unit before discontinuing the test because it is necessary that agreement be obtained in these balances before the test data can be considered valid. (5.4)

6. Computation of Results

Reliability of Data. The heat and material balances on the absorber can be considered as a measure of the reliability of the data and proot of attainment of steady state conditions. These balances must agree within the limits prescribed by a statistical treatment of the data based on either the observed standard deviation or the acknowledged limits of accuracy for all measurements involved. In the event of a disagreement in the material balance within the limits of accuracy, the observed values may be adjusted based on the data considered more accurate. In the case of a solute material balance this will generally require an adjustment of the feed gas composition to equal the sum of the amounts in the rich liquid and the lean gas less the amount in the lean liquid. Alternatively, if the feed gas concentration should be known with greater accuracy, the rich liquid concentration may require adjustment. (6.1)

Calculation of Performance by Step-Wise Method—Theoretical Plates. When the requirements of the previous section have been fulfilled the number of theoretical plates in the absorber can be calculated by any of the well known techniques.[5,6] Overall plate efficiency may be calculated and Murphree plate efficiencies may be determined graphically as described in these references. For packed columns the HETP may be calculated. (6.2)

Calculation of Performance by Differential Method—Transfer Units. Mass transfer coefficients, number of transfer units and HTU values may be calculated also as described in the previous references. (6.3)

7. Interpretation of Results

A rigorous theoretical basis for correlating the performance data of absorbers has not yet been developed but several empirical methods have gained prominence in this field.

The tray efficiency in bubble plate absorption columns has been found to be consistent with the correlations of data on distillation columns developed by Drickamer & Bradford[3] and also by O'Connell.[4] Observed tray efficiencies may be plotted against similar functions for purposes of confirming this correlation or developing a better correlation for absorbers. (7.1)

The two-film theory assumes the resistance to mass transfer in an absorption column to be composed of two independent resistances, one dependent upon the liquid flow rate and the other dependent upon the gas flow rate. If the gas film coefficient is assumed to vary as the 0.8 power of the gas rate similar to film coefficient in heat transfer, a plot of the reciprocal of the mass transfer coefficient against the 0.8 power of the gas rate for constant liquid rates should give a straight line. As discussed in the previous references, the data indicate that there is some interdependence of the film coefficients on the flow rates of the other phases so it is not reliable to extrapolate or interrelate the data on different systems based on this theory. The two-film theory finds its best application as a method of interpolation of performance on a particular system. (7.2)

The concept of two independent film HTU values is also discussed in these references. This leads to a straight line when the over-all (HTU) based on the gas concentrations are plotted against $\frac{KG}{L}$. The theory also leads to a straight line when over-all (HTU) values based on the liquid concentrations are plotted against $\frac{L}{KG}$. The data generally deviate from a straight line but by drawing the best curve through the data a reasonably reliable method of interpolation is available. (7.3)

Since all the proposed methods of correlation are empirical, extrapolation of the performance of an absorber to conditions outside the range investigated is uncertain. (7.4)

Evaluation of Results for Acceptance Test. For the reasons given in the last paragraph of the previous section all possible efforts should be made to conduct the acceptance test for an absorber at the design conditions. A comparison of the predicted and observed compositions and temperatures of the product streams will immediately indicate whether the absorber is performing according to the specifications within the limits of accuracy of the experimental data. If the absorber cannot be supplied with the design feed conditions, the extrapolation of the test data to the design condition will have to be decided by agreement between the parties involved. The following sections are suggested methods for reaching such agreement. (7.5)

Extrapolation Based on Performance of Similar Equipment. If performance data are available on a similar unit or if a correlation of the performance had been developed on pilot plant or other similar designed equipment extrapolation may be on the basis of these correlations. (7.51)

Extrapolation Based on Equipment Performance Under Specified Conditions. If other performance data are unavailable and a general method of correlation for the performance of the particular equipment cannot be established, the test run should be made on the absorber under an arbitrary set of conditions to give data relative to the original design conditions. The following sections describe several methods for establishing these test conditions. These conditions must not be outside of the acknowledged

operating range of the equipment. (7.52)

When the gas feed to the unit is greater than the design conditions, the design conditions can be established for the period of the test by bypassing the excess gas around the absorber. (7.521a)

When the maximum gas feed available is less than the design conditions, the absorber should be operated at the design rate of liquid flow, and under these conditions, the absorbed fraction of the desired component in the gas should not be less than design value. Within limits, the absorbed fraction should theoretically be greater, but the exact increment cannot be definitely established from available general correlations. The satisfactory performance of the absorber under these conditions will supply the same fractional recovery from the gas as in the original design. (7.521b)

If the concentration of solute in the feed gas is higher than given in the design specifications, provision may be made to recycle some of the weak gas from the absorber to the feed for the duration of the test, and the gas feed rate adjusted to the original quantity and concentration. If this cannot be accomplished readily, the liquid feed rate may be adjusted in proportion to the ratio between the actual concentration and the design concentration. The unit may then be considered satisfactory if the absorbed fraction of the solute is not less than the design under which conditions the concentration in the rich liquid must be substantially the same as in the original design. (7.522a)

If the concentration of the solute in the feed gas is lower than given in the design specifications, the same fractional approach of the gas stream to equilibrium with the feed liquid should be obtained with the design ratio of liquid to gas rates as in the original predictions. When the feed liquid is free of the desired component so that it exhibits no partial pressure, this fractional approach to equilibrium corresponds to the fraction absorbed; and in this case, the yield will be maintained at the expense of concentration in the rich liquid solution. (7.522b)

If the lean liquid feed contains less solute than in the original design, sufficient solute or rich solution may be added to the liquid to give the design concentration for the period of the test. (7.523a)

If the lean liquid feed contains more solute than in the original design, the lean gas leaving the absorber should contain a solute concentration not more than the design concentration plus the difference between the solute partial pressures from the actual feed and from the original design feed concentration. (7.523b)

If the feed gas is colder than the design temperature, the absorbed fraction should not be less than the design value except in cases where there is an adverse effect of temperature on the physical properties of the liquid or where the reaction rate may decrease to a point at which it may be controlling. Under these conditions, it will be desirable to preheat the feed to the design temperature during the test. (7.524a)

If the feed gas is hotter than the design temperature, the liquid rate may be increased to a rate calculated from a heat balance to maintain the temperature of the lean gas leaving the absorber at the design value. Under these conditions, the fraction absorbed should not be less than the design value. (7.524b)

If the lean liquid feed is colder than the design temperature, the absorbed fraction should not be less than the design quantity except in the cases noted in 7.524a. In these latter cases, the liquid feed should be pre-heated to the design temperature for the duration of the test. (7.525a)

If the lean liquid feed is hotter than the design temperature, the lean gas from the absorber shall contain not more solute than the design amount plus the difference between the partial pressures of the solute from the liquid at the actual temperature and at the design temperature. (7.525b)

The foregoing sections are based on a deviation of only one of the variables from the design value. They may also serve as a basis for selection of a representative set of conditions when more than one variable differs from the original design basis. (7.526)

Here is complete text of other sections

1. Purpose and Scope

Purpose. The primary purpose of this procedure is to provide standard directions for conducting and interpreting performance tests on absorption equipment. (1.11)

An additional purpose is to provide a standard procedure which can be used for investigating the performance of absorbers and for developing general correlations thereof. The specific objects in these tests are to: (1.12)

Accumulate data on the degree of absorption in different units. (1.121)

Accumulate data on the pressure drop in different units. (1.122)

Accumulate further data useful for the design and operation of absorbers; such as loading and flooding points and performance data on new types of packing or vapor-liquid contactors, etc. (1.123)

A supplementary purpose of this procedure is to suggest a standard method for establishing conditions for an acceptance test on an absorber and for comparing the

results with the original design conditions. (1.13)

Scope. The scope of this testing procedure is limited to absorption of gases in liquids and does not include adsorption of gases on solids. It covers any equipment in which the prime purpose is to effect a transfer of material from a gas phase to a liquid phase by direct contact between the phases. The gas phase may contain non-absorbable gases in any concentration. The procedure also includes absorption in which chemical reaction takes place. (1.2)

2. Definitions and Descriptions of Terms

Fluid Streams. The different streams entering and leaving an absorber are identified schematically by name and symbols on Figure 1. Any consistent set of units may be used in specifying the quantity and properties of each of the streams. One consistent set is given in Section 8. (2.1)

The feed gas refers to the solute-rich gas entering the absorption system. The total quantity flow rate of feed gas is designated G_1. The concentration of its solute is designated y_1, and its enthalpy per unit quantity is designated H_{G1}. (2.11)

The lean liquid refers to the fresh solvent introduced to absorb the solute. The total quantity flow rate of lean liquid is designated L_2. The concentration of its solute is designated x_2 and its enthalpy per unit quantity is designated H_{L2}. (2.12)

The exit gas from the absorption system is called the lean gas. The total quantity flow rate of lean gas is designated G_2. Its residual concentration of solute is designated y_2 and its enthalpy per unit quantity is designated H_{G2}. (2.13)

The liquid containing the absorbed solute, leaving the system is called the rich liquid. The total quantity flow rate of rich liquid is designated L_1. Its concentration of solute is designated x_1 and is enthalpy per unit quantity is designated H_{L1}. (2.14)

Material Balances. A total material balance requires that the sum of all streams entering equals the sum of all streams leaving. (2.2)

$$L_2 + G_1 = L_1 + G_2$$

The solute material balance requires that all solute entering equals the sum of all the solute leaving. (2.22)

$$L_2x_2 + G_1y_1 = L_1x_1 + G_2x_2$$

The inert gas material balance requires that the quantity of inert gas entering equals the quantity leaving. (2.23)

$$G_1 (1\text{-}y_1) = G_2 (1\text{-}y_2)$$

This equation assumes that the solubility of inert gas in the rich liquid is negligible. If it is appreciable the quantity must be added to the right hand side of the above equation.

The solvent material balance requires that the quantity of solvent entering equal the quantity leaving. (2.24)

$$L_2 (1\text{-}x_2) = L_1 (1\text{-}x_1)$$

This equation assumes that the vapor pressure of the solvent is negligible in the exit gas. If it is appreciable the quantity must be added to right hand side of the above equation.

Absorbed Fraction. The absorbed fraction of a solute is equal to the quantity of solute absorbed by the rich liquid divided by the quantity of solute in the feed gas. It is also equal to unity minus the unabsorbed fraction. The unabsorbed fraction is equal to the quantity of solute in the lean gas divided by the quantity in the feed gas. According to these definitions: (2.3)

$$\text{Fraction absorbed} = \frac{L_1x_1 - L_2x_2}{G_1y_1} = 1 - \frac{G_2y_2}{G_1y_1}$$

Heat Balance. The heat balance requires that the sum of all heat quantities entering the absorber equals the sum of all heat quantities leaving. The calculation of the enthalpies of the different streams should include the heats of reaction and dilution or mixing of the components to give the actual enthalpy of the final mixture. If the total intercooler duty is taken as Q the heat balance on the absorber is given as:

$$L_2H_{L2} + G_1H_{G1} = L_1H_{L1} + G_2H_{G2} + Q$$

In the case of small unlagged absorbers it will be necessary to include the heat effects due to radiation to obtain a satisfactory heat balance. This heat effect will depend upon the relationship between the operating temperature and the ambient temperature. (2.4)

Liquid and Gas Holdup. The liquid holdup of a system refers to the amount of liquid retained in the system under specified conditions. (2.51)

The static holdup of the system is the amount of residual liquid which cannot be drained from the system after all flows are shut down. In a packed column it represents the liquid retained in the packing after it has been completely wetted and allowed to drain until no additional liquid drops out of the packing. (2.511)

The dynamic holdup is the amount of that liquid retained in the system while it is operating under particular gas and liquid throughputs. This holdup varies with the gas and liquid rates. In the case of a packed column it consists of the static holdup plus the liquid which drains out of the packing when the flow rates are shut down. (2.512)

Gas holdup refers to the volume of gas present in the system under specified conditions. In general, an increase in the liquid holdup decreases the gas holdup but since the volume of liquid in the system is usually small with respect to the gas volume the dynamic and static gas holdups differ very little. (2.52)

Equilibrium Conditions. Equilibrium conditions obtain when the concentrations of solute in the gas and liquid phases are such that no further changes in the solute concentration occur when the phases are allowed to remain in contact. Equilibrium concentrations must be determined for different total amounts of solute in the system. They may be more accurately defined as static equilibrium conditions. (2.6)

Steady-State Conditions. In contrast to the prevous definition, steady-state represents a dynamic equilibrium condition. It has in many cases been loosely referred to simply as equilibrium conditions, and care must be taken to distinguish it from the previous static equilibrium. Steady-state occurs under flow conditions when no further changes take place in the concentrations in either the gas or liquid exit streams. Steady-state conditions differ with the absolute and relative flow rates of the gas and liquid streams. The concentrations of the gas and liquid streams under the different flow rate conditions form the basis for evaluating the performance of absorption equipment. (2.7)

Methods for Expressing the Performance of Absorption Equipment. In the operation of an absorber the factor of major importance is the fraction of absorption obtained. This is usually the end result of the design calculations. In order to correlate the performance of absorption equipment under the different operating conditions, it is necessary to introduce fundamental concepts of the actual mechanism for the transfer of solute from the gas to the liquid phase. (2.8)

Theoretical Plate. The countercurrent flow of the gas and liquid through a number of stages provides the basis for the concept of a theoretical plate. When the gas leaving each of the stages is in equilibrium with the liquid leaving the same stage a theoretical plate is obtained. In practice the approach to equilibrium between the two phases in an actual plate in a column is generally less than 25 percent. This degree of approach is called the Murphree plate efficiency and may be defined based on either the liquid or gas concentrations. These are respectively:

$$\eta_{ML} = \frac{x_{n+1} - x_n}{x^*_{n+1} - x_n}$$

$$\eta_{MG} = \frac{y_n - y_{n-1}}{y_n - y^*_{n-1}}$$

These two efficiencies generally differ and also differ from the over-all plate efficiency which falls intermediate between the two values. The over-all plate efficiency is equal to the number of theoretical plates required for the actual separation obtained in a column divided by the actual number of plates in the column. (2.81)

Transfer Unit. As the plate efficiency approaches zero the differential amount of solute transferred from the gas phase to the liquid phase in each differential plate is assumed to be transferred under the concentration driving force existing between the actual concentration on this differential plate and the concentration in equilibrium with the other phase. Integrating the differential amount of solute transferred in the differential plate divided by the driving force, over the entire concentration range obtained in the column gives a value which has been called the number of transfer unit. This number depends upon the concentrations considered and for liquid and gas concentrations the definitions are respectively:

$$N_{tx} = \int_{x_2}^{x_1} \frac{dx}{x^*\text{-}x}$$

and

$$N_{ty} = \int_{y_2}^{y_1} \frac{dy}{y\text{-}y^*}$$

The two numbers differ and it has been observed that the number of theoretical plates in a given separation lies intermediate between the two numbers of transfer units obtained. (2.82)

Mass Transfer Coefficients. Another method for evaluating the performance of absorption equipment is through the concept of mass transfer coefficients. The mass transfer coefficient is defined as the quantity of solute transferred per unit of time, per unit of effective column volume and per unit of driving force. The value of the coefficient will depend on whether gas or liquid concentrations are used as the driving force and when the integrated mean driving force is used the coefficients are directly related to the transfer units. Thus the mass transfer coefficients are expressed in gas and liquid concentrations as: (2.83)

$$K_{Ga} = \frac{G(y_1 - y_2)}{M_G lP(y - y^*)} = \frac{G}{M_G lP} N_{ty}$$

and

$$K_{La} = \frac{L(x_1 - x_2)}{M_L lP(x^* - x)} = \frac{L}{1P_M} N_{tx}$$

Height Equivalent to a Theoretical Plate. When the number of theoretical plates required to achieve the degree of absorption observed in a packed column has been calculated, the height of the column divided by this number of theoretical plates gives the height equivalent to a theoretical plate (HETP). (2.84)

Height of a Transfer Unit. The number of transfer units calculated for an observed degree of absorption divided into the height of column giving this degree of absorption is the height of a transfer unit (HTU) and is different for the gas and liquid concentrations. These heights are directly related to the mass transfer coefficients in the corresponding concentrations, thus (2.85)

$$(HTU)_{OG} = \frac{G}{G_{Ga} M_G P}$$

and

$$(HTU)_{OL} = \frac{L}{K_{La} \rho_M}$$

For simplicity these definitions have been expressed for the case of low concentrations of solute in the gas and liquid streams so the total amounts of the streams are substantially constant throughout the absorber. More rigorous definitions applicable to higher concentrations have also been developed. (2.86)

Flooding Conditions. Flooding conditions are generally considered to represent the maximum capacity of a column in a given service. The maximum vapor rate depends upon the liquid downflow rate so flooding will vary for different vapor-to-liquid ratios. Two different methods have been proposed for recognizing flooding. One depends upon visual observation of a liquid layer build-up at the top of the packing. The other depends upon a particular change in the variation of pressure drop with vapor rate in the column and generally gives a slightly higher value. Care must be exercised in using reported flooding data because if visual flooding had been given it may be possible to operate slightly above the reported value. However since the performance efficiency generally decreases as flooding is approached, practical columns are operated sufficiently below flooding to give the economic optimum combination of throughput and performance efficiency. (2.9)

3. Test Conditions and Data

The following data are necessary to determine the heat and material balances on an absorber. Only at steady state will the heat and material balances check. (3.1)

The compositions of all fluids entering and leaving the absorber. (3.11)

The flow rates of all fluids entering and leaving the absorber. When coolant is used in an intercooler its flow rate must also be measured. (3.12)

Temperatures of all fluids entering and leaving the absorber should be measured. When heat is added or removed in some section of the absorber, terminal temperatures of all fluids, including the heat transfer medium in this section should be measured. (3.13)

Pressures of all streams entering and leaving the absorber should be measured. (3.14)

In mechanically agitated absorbers the power input should be determined either from the input speed and measured torque or from the power input after correcting for the transmission losses. (3.15)

The following physical chemical data are required for calculating and interpreting the performance data and also for developing or testing general correlations of the performance. (3.2)

Partial pressure or solubility data of the solute over the operating temperature range. (3.21)

Heat effects involved in the absorption process such as latent heat, heat of solution or dilution and heat of reaction when chemical change occurs. (3.22)

Specific heats of all fluid streams over the operating temperature range and any other data necessary to calculate the enthalpy difference in all fluids passing through the exchange. (3.23)

Physical properties necessary to convert the measurements to a common basis are molecular weight and density or specific gravity. (3.24)

Other physical properties useful in developing and testing correlations such as viscosity, thermal conductivity, diffusivity and surface tension. Values of these functions over the operating temperature of the absorber should be known so that suitable average quantities can be determined. (3.25)

4. Methods of Measurement

Due to the wide variety of factors involved, a choice of temperature, pressure, pressure drop and flow measurement instruments may have to be dictated by the specific problem at hand. Methods of analysis may also be subject to selection based upon the specific problem. The following methods are considered normal for many absorbers.

Temperature Measurement. The recommended technique for temperature measurements is given in A.I.Ch.E. Standard Testing Procedure for Heat Exchangers, Section 1, Sensible Heat Transfer in Shell and Tube-Type Equipment.[1] When the temperature indicators and recorders supplied with the equipment have been installed with these or the equipment manufacturers' specifications they may be calibrated and used for the tests. (4.1)

Flow Rate Measurement. The recommended technique for measurement of flow rate is given in A.I.Ch.E. Standard Testing Procedure for Heat Exchangers, Section 1, Sensible Heat Transfer in Shell and Tube-Type Equipment.[2] Any flow meters installed according to these or the manufacturers' specifications may be used for the test. They should be calibrated on the particular stream at the normal operating conditions wherever possible. (4.2)

Measurement of Pressures and Pressure Drop. Where practical, open tube manometers are recommended for pressure measurement. At high pressures Bourdon tube instruments are satisfactory for pressure measurement. Any available instrument installed in accordance with the manufacturers' specifications and calibrated in place will suffice. (4.31)

For pressure drop measurements differential pressure gages or manometers are preferred. If single pressure instruments are used, two sets of measurements should be taken for each differential pressure with the instruments interchanged and the average of the differences for the two sets of readings may be used. In measuring pressures on absorbers it will be necessary to prevent any line leading to an instrument from becoming filled with liquid from entrainment or from condensation of vapors. A carefully adjusted flow of non-condensible purge gas through the line is frequently used. Another method, particularly useful on equipment under pressure consists of filling the line with liquid and then allowing for the static head of liquid in the two lines. Fluctuating pressure may be averaged by introducing a suitable snubber in the instrument line. (4.32)

Methods of Sampling. The major difficulty in obtaining a material balance for any particular solute in an absorber lies in taking a truly representative sample of the flowing stream. Selecting a sampling point where the stream is likely to be of uniform composition will minimize the error due to non-uniform stream composition. Also taking a sample over a long period will average out the fluctuations of the composition but this will lengthen the duration of the test period and thus increase the chance of a drift of any of the control points. (4.4)

A reliable representative average liquid sample could be obtained from a surge tank before and after the absorber. This tank should preferably be agitated and only used to collect the stream after it has been established that steady state conditions have been reached. If it is continually on stream its contents must be incuded in the total liquid phase holdup for purposes of estimating the time to approach steady state and time of the run period in Section 5. If it is not practical to introduce this intermediate surge capacity, a side-entering mixer placed in the bottom of the absorber below the liquid level would tend to keep the liquid discharge from the unit homogeneous and thus facilitate the liquid sampling. Agitated absorb-

ers do not present this same mixing problem but in such cases when the liquid holdup is low any variations in the gas or liquid feed rates will produce short-lived variations in the liquid sample and a time averaging sample would still be desirable. (4.41)

Gas samples present a greater problem because the volumes handled are so large that it is not possible to provide a surge tank with a reasonable holding time. The preferable point for sampling a gas is after it has passed through some restriction in the line such as an orifice or venturi meter or after it has passed through all the elbows or other flow disturbances in the line. This would suggest sampling the feed gas close to absorber entrance and the lean gas at the point where it enters the next processing unit or where it is exhausted to the atmosphere. (4.42)

In the case of a large duct it may be desirable to insert a perforated sampling pipe with a total hole area less than 75 percent of the cross sectional area of the pipe. The holes may be of the same diameter and equally spaced or preferably the diameter may be varied to withdraw a volume of gas proportional to the volume flowing in each particular area. (4.421)

Samples of gas and liquid streams may be taken periodically at equal time intervals or may be withdrawn continuously for the duration of the run period. Individual samples may be analyzed or may be combined to give a weighted average sample for analysis. Any combination of the periodic and continuous methods are suitable providing the samples of different streams are taken during the same time cycle. (4.43)

Methods of Analysis. Any method suitable for the desired solute may be used. Treatment of all or any particular method is beyond the scope of this procedure. Only basic procedures may be recommended. (4.5)

Liquid analyses are subject to the direct method of analyses either based on chemical methods or on physical methods when these are of sufficient accuracy. Use of physical methods of refractive index, density, viscosity, thermal conductivity, colorimetry, etc. allows continuous monitoring of the composition of the liquid stream. (4.51)

Gas samples may be analysed by either chemical or physical methods. (4.52)

When chemical methods are utilized the solute is generally absorbed from the gas by a solution containing an excess of reactant and the excess reactant in the final solution then determined by suitable chemical means. (4.521)

Physical methods that have been adapted to continuous indicators and recorders are thermal conductivity, heat of combustion and heat of absorption. Instruments utilizing physical methods should be calibrated on the particular gas stream. (4.522)

Power Measurement. In mechanically agitated absorbers the operating speed can be measured with a tachometer, stroboscope or a speed indicator on the center of the shaft or a surface speed indicator on the circumference of the shaft when the center is inaccessible. (4.61)

The torque of the input shaft may be determined by a strain gauge or other suitable device and the power input calculated from the torque and speed. (4.62)

Alternatively the power input to a motor may be obtained by a recording watt meter to balance out line variations and provide a continuous record. Actual power input to the absorber may be calculated allowing for the losses in the motor and the transmission system. (4.63)

Measurement of Liquid Holdup in Packed Columns. In order to estimate the time required between start-up and establishment of steady state conditions and the minimum time cycle for the periodic samples, the liquid holdup on the packing must be determined. The data may be available for the particular operating conditions or may be measured separately or on the existing unit. (4.7)

The column is brought up to operating conditions, and when the pressure drop becomes steady, the liquid feed and the gas feed are shut off. The liquid draining out of the column is noted by the increase in level in the bottom when the liquid draw-off is shut off or by measuring the amount of liquid drawn off to maintain the liquid level constant in the bottom of the column. This quantity represents the drainable holdup in the packing and several hours are usually required for all this holdup to drain off the packing. This must be added to the static holdup of the column to obtain the total. (4.71)

The static holdup of the packing per unit volume may be available from previous data on the particular packing. This may be used to calculate the holdup in the given column. If not available, the static holdup can be calculated by measuring the liquid retained on a known volume of packing. The sample of packing need only be sufficiently large to be representative of the packing in the large column, and will be larger for the larger packing sizes. The ideal sample is obtained by packing a small column of a diameter greater than eight times the nominal packing size by the same technique as employed in packing the large column. One method of determining the amount of retained liquid is by the difference between the weight of the dry packing, and the weight of the packing after submerging in the liquid and allowing to drain to constant weight. Another method consists of determining the difference between the weight of liquid required to submerge the packing and the weight of liquid recovered on draining the packing. With volatile liquids the loss of liquid by evaporation must be avoided during the prolonged draining period. Sealing the top of the column after the initial release of the liquid will prevent the evaporation of the liquid from the column during this draining period. (4.72)

Liquid holdup in tray columns may be measured by shutting the unit down and measuring the accumulation of liquid draining off the trays through the weep holes. (4.73)

If weep holes are not provided, the liquid level on one or more trays may be observed with an external manometer with one leg connected to the bottom of the tray and the other to the vapor space above the tray. (4.731)

Liquid holdup on the trays may also be estimated by observing the average froth level and multiplying by the proper correction factor for froth density which is usually about 0.3 (4.732)

If actual measurements are not possible holdup may be estimated by calculation from available correlations or data on related equipment. (4.733)

8. Notation

a = Effective surface of contact between phases per unit volume of packing, ft.^{2}/ft.^{3} (not used as separate variable)

G = Gas flow rate, lbs./(hr.) (sq. ft.)

H = Enthalpy, BTU/lb.

$(HTU)_O$ = Height of an overall transfer unit, ft.

K = Ratio of concentration in gas phase to concentration in liquid phase at equilibrium (dimensionless) $= \frac{y^*}{x}$

K_{Ga} = Overall gas transfer coefficient, lb. moles/(hr.) (ft.^{3}) (atm. driving force)

K_{La} = Overall liquid transfer coefficient, lb. moles/(hr.) (ft.^{3}) (lb. moles/ft.^{3})

l = Total height of packing, ft.

L = Liquid flow rate, lbs./(hr.) (sq. ft.)

N_t = Number of overall transfer units — dimensionless

P = Total pressure in absorber — atm.

Q = Heat duty of intercoolers — BTU/hr.

x = Concentration of solute in liquid — weight fraction

y = Concentration of solute in gas — weight fraction

η_{ML} = Murphree plate efficiency based on liquid concentrations

η_{MG} = Murphree plate efficiency based on gas concentrations

ρ = Density, lbs./ft.^{3}

Subscripts

1 — refers to rich end of absorber

2 — refers to lean end of absorber

G — refers to gas phase concentration

L — refers to liquid phase concentration

M — refers to mean value

n — refers to plate numbers starting at top or dilute end of absorber

Superscript

* — refers to concentration in equilibrium with other phase at given point in column

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Centrifugal Pump Packings and Seals

Included in this report on installation and maintenance is a guide to packing troubles, their cause and cure.

Harold Woodhouse
Dean Hill Pump Company
Indianapolis

HANDBOOK

Part 1
Packing Boxes and Glands

Part 2
Packings

Part 3
Mechanical Seals

Part 4
Mechanical Seal Maintenance

Part 5
Packing Maintenance

SOME TIME ago newspapers carried a report about a big automobile race being lost because of the failure of a 50-cent magneto part. The car owner, with murderous intent, promptly chased the parts supplier who lived because he could run faster. Centrifugal pump packing seems an insignificant item in a large refinery but it causes more pump shutdowns than anything else. When one considers that a refinery can easily have more than a thousand pumps the importance of the use of proper packing and correct maintenance cannot be over emphasized.

Many pumps should be shipped without the packing installed. Very few companies ship pumps this way and some others who have done so in the past have given up the practice. The reason being that sometime between shipment and start-up at the site, the loose packing usually disappears. Another factor is that the pump is properly packed and then adjusted during factory test and this helps guard against improper packing and adjustment on the site and consequent failure during initial start-up.

Various manufacturers have reported that when a pump containing graphite packing is allowed to stand for a lengthy period the shaft or shaft sleeve in contact with the packing becomes etched, pitted or corroded. The greatest incidence of trouble seems to be when the shaft or shaft sleeve is carbon steel or iron. Some trouble is reported even when they are monel or stainless steel. Bronze seems to be the least affected.

This explains some pump failures during initial start-up. The condition cannot be corrected until the shaft or sleeve is reworked or replaced. When a lengthy shutdown of an installed pump is contemplated it may be advantageous to remove the packing.

A good rule, on the receipt of new pumps which are not to be put in service within 30 days or with installed pumps which are to be shut down for a greater period than this, is to remove packing and grease shaft or sleeve and stuffing box bore.

Repacking the Stuffing Box. To repack a stuffing box the first obvious step is to remove the old packing. Always remove and replace *all* of the old packing. Do not reuse some of the rings because they look all right.

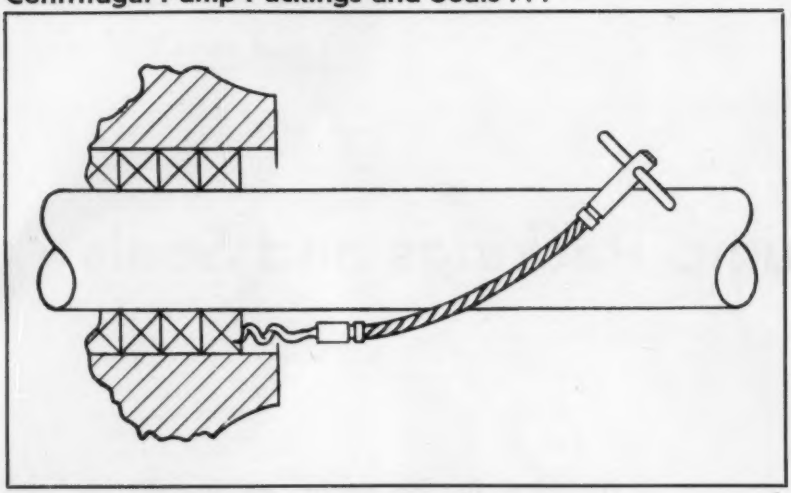

FIGURE 1—Corkscrew puller used for packing removal.

If, for instance, the three most accessible rings only are replaced, then they will be the only rings compressed when the gland is tightened. Consequently, the new rings will have to do all of the work of sealing the gland and an accelerated packing wear will result. The old rings, having been previously compressed, will move as a unit and fail to provide any sealing effect. In view of the various costs involved in shut-down time of a pump, saving on packing is not economically justified.

Removing Packing. To remove packing, a puller, as illustrated in Figure 1, can be used. It consists of a short corkscrew section, on the end of a piece of flexible wire, attached to a handle. If the packing should break up during the effort to pull it out, as the cork in a bottle of wine sometimes does, all the broken pieces should be removed so as to have a clean and clear box before inserting the new packing. Any section of old packing ring that is not removed will make it impossible to pack the pump properly. This may sound elementary, but it is surprising how many pump troubles spring from elementary causes.

If the information is not separately and immediately available in writing, it is important that the person packing the pump note the number of packing rings in each gland and their arrangement. If there is a lantern ring in the box, it is usually arranged so there are the same number of rings on each side but the packing rings are not always all the same material or construction. For instance, where the pressure is high, the rings at the bottom of the stuffing box, next to the gland and either side of a lantern ring may be of a harder, less flexible construction (metallic or semi-metallic) than the remainder of the rings. This is to prevent their extrusion into the clearances between the bores of the throat bushing, lantern ring, gland and shaft. It is important to maintain this arrangement.

To determine the packing thickness do not measure old packing. Halve the difference between the stuffing box bore and the shaft diameter as shown in Figure 2.

Installing New Packing Rings. In cutting out the new packing rings, the correct way for coil packing is to wrap it around an arbor of the same size as the pump shaft as shown by Figure 3. This produces rings as in Figure 4 rather than Figure 5. The latter results when packing is cut out of a flat strip leaving a triangular open area which permits liquid leakage to bypass the packing. It also allows adjoining rings to squeeze partly into the open space so that the gap can never fully close. Generally, packing rings do not require an expansion gap as do engine piston rings.

However, channel type packing rings with a lead core may require a slight gap.

If the packing is slightly large, never attempt to flatten it with a hammer. Lay it on a clean flat surface and roll it with a piece of pipe like mother did with a rolling pin on a piece of dough.

To put a ring over the shaft do not pull it apart since it may break opposite the cut ends. Twist it over the shaft as shown in Figure 6.

Foil wrapped packing should be installed so that the foil edges at the bore face the direction of rotation, otherwise, the thin edges flake off and reduce packing life.

It is helpful, at assembly, if new metallic rings are swabbed with a lubricant. Note, however, that metallic packing should be used only with hardened sleeves since it would tend to cut softer materials.

The rings should be tamped separately in place. This is particularly necessary with plastic or metallic packing. Preferably, this may be done with a dummy gland which can be a split, plain sleeve of metal or wood which fits over the shaft.

The dummy gland's outside diameter should be slightly smaller than that of the stuffing box bore. A

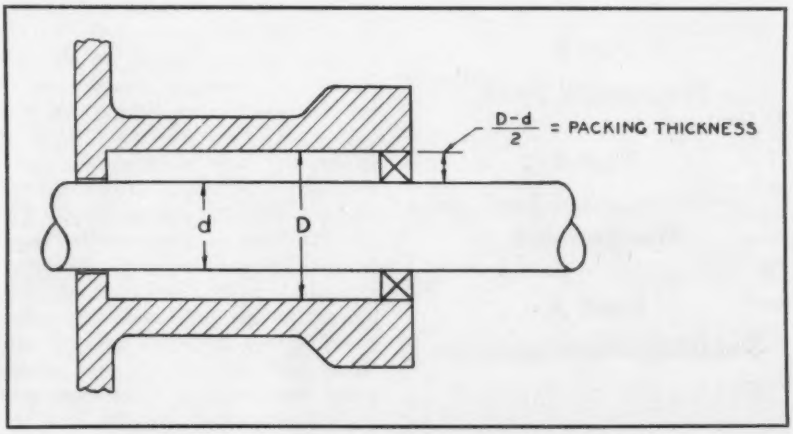

FIGURE 2—For replacement, do not measure the old packing thickness.

simpler substitute, but not as good, is a square-ended stick. The last few rings may be pushed into place using the gland.

The packing ring joints should be staggered as each ring is put in the stuffing box (180 degrees if only two rings are required per box, 120 degrees for three rings, 90 degrees for four or more).

If there is a lantern ring, it must be installed so that *when the packing is compressed* it lines up with the cooling liquid opening.

After each ring is tightly in place (woven and braided packing need not have each individual ring compressed), each ring should be dipped in oil and pushed to the bottom of the stuffing box. It is advantageous to rotate the shaft a few times by hand to "gloss" the packing. When the box is fully packed (the packing should never protrude past the stuffing box face so that the gland may be properly started in stuffing box bore) and the last ring has been firmly tightened, back off the gland nuts and retighten them *finger-tight* only. This allows the packing to expand as it warms up.

Packing Lubrication. If the pump is handling hydrocarbons, solvents or similar non-lubricating liquids, the pump gland should be fitted with a grease lubricator and a non-solvent grease used. Sealing of the stuffing box by using a sealing liquid or lubricator is required when a vacuum exists on the pump suction (refer to Part 1 of this series entitled 'Packing Boxes and Glands').

Apart from the mechanics of packing certain other points should be kept in mind:

The pipe supplying the gland sealing water should be fitted tightly so that no air is brought in. A small quantity of water entering the suction at this point may make it difficult to get the pump primed at starting and may result in the pump losing its suction during operation. This causes the pump to run dry, and complete failure may occur with considerable damage to the rotating elements and stationary case wearing rings.

If water or other liquid to be pumped contains acid, dirt or grit, sealing water or compatible fluid from some clean and clear outside source should be piped to the stuffing boxes to prevent damage to the packing and shaft or shaft sleeve (see Part 1 of this series).

Do not use untreated hemp or flax. They will score shaft or sleeve. Use only packing grade and combinations recommended by pump or packing manufacturer.

Before using aluminum packing, particularly on light hydrocarbons, check your refinery regulations regarding its use. One refinery fire was attributed to its use and while this opinion has not been generally accepted, there might be some opposition to its use in a specific refinery.

Many pump failures occur because inexperienced maintenance personnel note that liquid is dripping from a gland and they endeavor to stop it by tightening the gland bolts. For a very short period the leakage is stopped. The packing then becomes overheated and burns or scores the shaft or shaft sleeve. The pump must be shut down; the packing is ruined and, as likely as

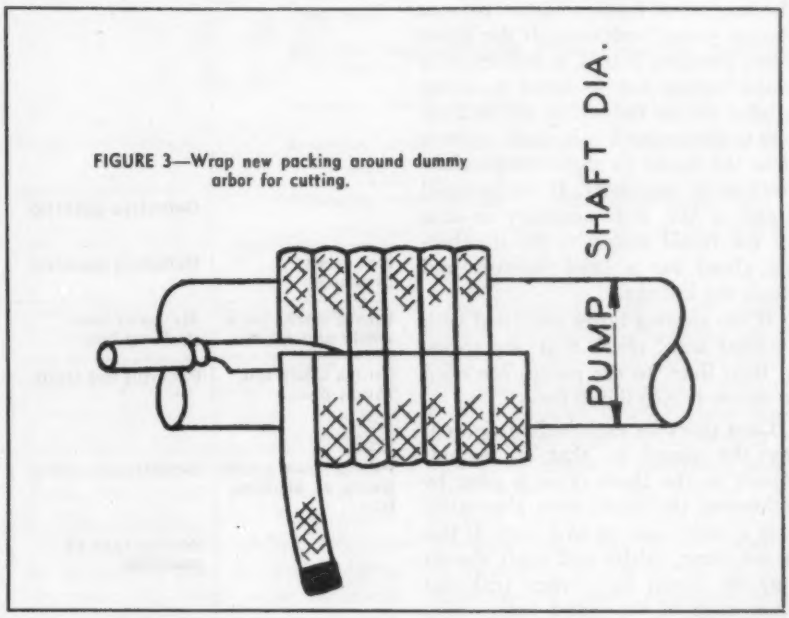

FIGURE 3—Wrap new packing around dummy arbor for cutting.

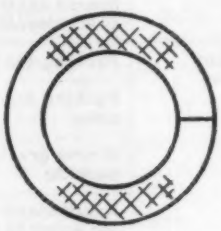

FIGURE 4—Cutting on an arbor produces perfect rings.

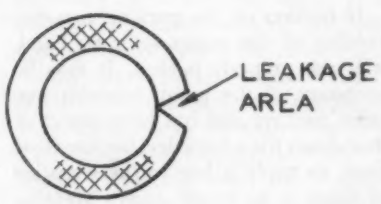

FIGURE 5—Cutting out of a strip produces triangular open area.

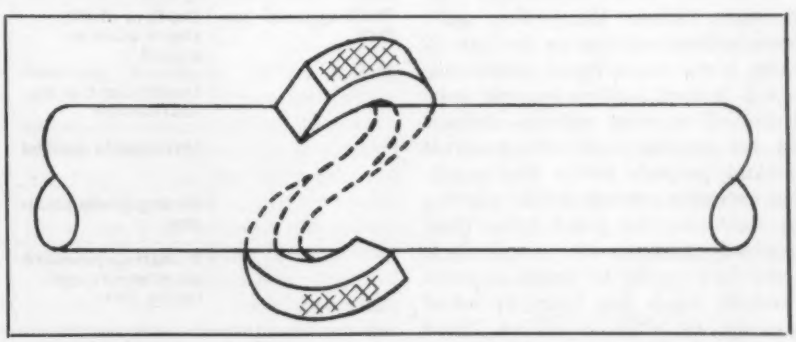

FIGURE 6—Twist packing ring over shaft to prevent breakage opposite the cut ends.

not, an expensive new shaft or shaft sleeve is required, if they cannot be remachined.

A fundamental requirement with all packings is that they be lubricated at all times and this necessitates constant leakage.

When the gland is properly adjusted and the packing has been "run in," only a few drops of leakage a minute is necessary, but it is *essential.*

When a smothering gland is used, the amount of leakage cannot be seen during normal operation. If the liquid being pumped is cool, a deficiency of gland leakage may be noted by laying a hand on the outside of the stuffing box to determine if it is much warmer than the liquid (a slight temperature rise can be expected). If the pumped liquid is hot, it is necessary to shut off the liquid supply to the smothering gland for a brief interval and check the leakage.

If the stuffing boxes are fitted with external seals, check that any valves in their lines, to the pump, are open to ensure sealing liquid flow.

Care must be exercised in tightening the gland so that it remains square to the shaft. This is done by tightening the gland bolts alternately only a slight amount at a time. If this is not done, shafts and shaft sleeves may be scored by contact with the inner edge of the gland bore which will lead to rapid packing failure.

If friction of the packing prevents turning of the pump rotor by hand, it is not properly packed. It may be necessary, if the pump contains metallic packing and has been stored or shut down for a considerable length of time, to apply a bar to the coupling to force it to break away. Metallic packing has a tendency to stick after a period of nonuse.

When the pump is started, it is desirable to have the packing quite loose without causing an air leak. If there is too much liquid gland leakage, it is good practice to apply some heavy oil or other suitable lubricant on the packing until the pump is working properly rather than applying excessive pressure to the packing by tightening the gland bolts. Then gradually tighten the gland. It is quite important to watch a pump carefully for a few hours at initial start-up, or after re-packing. Since one may observe that, although the

TABLE 1
Packing Troubles, Their Cause and Cure

TROUBLE	CAUSE	CURE
No liquid delivered	Lack of prime	Packing too loose or defective, allowing air to leak into suction. Tighten or replace packing and prime pump.
Not enough liquid delivered	Air leaking into stuffing box	Check that there is some leakage through stuffing box while operating—if no leakage after reasonable gland adjustment new packing may be needed or Lantern ring may be clogged or displaced and may need centering in line with sealing liquid connection or Sealing liquid line may be clogged or Shaft or shaft sleeve below packing may be badly scored and allowing air to be sucked into pump.
	Defective packing	Replace packing and check smoothness of shaft or shaft sleeve.
Not enough pressure	Defective packing	As for preceding.
Pump works for a while and quits	Air leaks into stuffing box	See preceding.
Pump takes too much power	Packing too tight	Release gland pressure. Retighten reasonably. Keep leakage flowing—if none check packing, sleeve or shaft.
Pump leaks excessively at stuffing box	Defective packing	Replace worn packing. Replace packing damaged by lack of lubrication.
	Wrong type of packing	Replace packing not properly installed or run-in. Replace improper packing with correct grade for liquid being handled.
	Scored shaft or shaft sleeves	Put in lathe and machine true and smooth or replace.
Stuffing box overheating	Packing too tight	Release gland pressure.
	Packing not lubricated	Release gland pressure and replace all packing if any burnt or damaged.
	Wrong grade of packing	Check with pump or packing manufacturer for correct grade.
	Insufficient cooling water to jackets	Check if supply line valves opened or line clogged.
	Stuffing box improperly packed	Repack.
Packing wears too fast	Shaft or shaft sleeve worn or scored	Remachine or replace.
	Insufficient or no lubrication	Repack and make sure packing loose enough to allow some leakage.
	Improperly packed	Repack properly making sure all old packing removed and box clean.
	Wrong grade packing	Check with pump or packing manufacturer.
	Pulsating pressure on external seal liquid line	Makes packing move and prevents it taking a 'set'. Remove cause of pulsation.

gland was adjusted to allow a substantial leakage, after a period of time (which might be twenty minutes or several hours) the leakage has stopped or decreased to the point where it no longer provides sufficient lubrication and the packing starts to heat up. This is caused by swelled packing resulting from the absorption of water, or other pumped liquid, and an increase of temperature. The amount of swelling varies with the different packings manufactured. Although it is an undesirable characteristic it may be necessary to tolerate this condition for other desirable characteristics of the packing.

If the stuffing boxes should overheat, stop the pump and cool off the boxes before starting again. If necessary, repeat this procedure several times to "break-in" the packing and allow liquid to seep through for lubrication.

If there is liquid pressure at the back of the first ring in the bottom of the box, it is recommended that the gland bolts *not* be loosened while the box is hot as the complete set of packing may be pushed out as a unit and leakage may occur around the outside of the packing.

In common, cool water, double-suction pump applications, to ensure protection of the packing from burning, one can leave out the last ring of packing and avoid tightening the packing too much for initial start-up after repacking. Then, after the pump has run awhile the last ring may be added and tightened. This scheme may not work if there is too much suction lift on the pump as it may prevent the pump from acquiring and maintaining a prime. In such high lift conditions it may be necessary to tighten the packing gland at start-up to maintain a prime. But, this should not be done until a few starting attempts have shown that the pump will not retain its prime and then the gland tightening should be a minimum to avoid burning the packing or scoring the shaft or sleeve. Immediately after the pump is primed and running satisfactorily, the gland should be backed off to permit a leakage.

If the pumped liquid is in excess of 200 F. it is most likely that the pump will have been provided with water, or other liquid, cooled packing boxes and glands. Check that valves in these coolant lines are open and that liquid is being delivered to the pump. These coolant lines should be independent of, and not in series with, any coolant lines to the bearing housings. If, for any reason there is an extreme shortage of water, although it is by no means a *usual* arrangement, the two should be in series. Then, the coolant would go to the bearing housing first. The coolant flow should then be restricted so it is not too cold leaving the bearing housing, since this could cause the outer race of a ball bearing to shrink while the inner race was being expanded by a hot shaft. The result of this condition would be an early bearing failure.

If after a pump has been running satisfactorily it is noted that the driving power required is too high, it may be that the packing glands are too tight. The gland pressure should then be released and slowly retightened, watching both the gland leakage and the power input for the best compromise.

Packing Troubles. When packing wears too quickly, inspect the shaft or sleeve for signs of surface roughness, which may be caused by corrosion or the result of scoring by overheated packing. In instances where a pump speed has been increased, the greater head developed may have necessitated a change from soft, graphite-asbestos type to a metallic packing which requires the use of hardened sleeves as it scores soft metals.

An occasional source of packing trouble is caused by "run-out" of the shaft or sleeve. The run-out pushes the packing out of contact with the shaft and causes an excessive leakage. The operator then tries to reduce the leakage by excessive tightening of the gland bolts which can lead to a variety of troubles. If this is the suspected source of trouble, it is possible, in some instances, to mount an indicator on the pump casing to check the shaft or sleeve. In others, it is necessary to remove the entire rotor to check it while mounted on "vee-blocks" or between lathe centers.

Any particular trouble with a pump's performance may originate from a number of different directions. The causes of trouble indicated in Table 1 are only those which might *possibly* come from packing, seals or shaft or shaft sleeves. The actual cause of trouble in a specific instance may be caused by other conditions.

A great many brand names of greases for packing are available and for ordinary cool water service probably all are acceptable. For special applications the problem should be referred to the pump or grease manufacturer.

Table 2 is a list of packings which may be used as a guide to the basic materials to be used with various pumped media.

TABLE 2

Guide to Packings for Various Media

Medium	Centrifugal and rotary shafts
Steam, High Pressure	Asbestos. Metallic. Semi-metallic Plastic (loose fill)
Steam, Low Pressure	Asbestos. Metallic. Semi-metallic Plastic (loose fill)
Water, Hot	Asbestos. Semi-metallic. Plastic (loose fill). Mechanical seals.
Water, Cold	Asbestos. Flax, jute or ramie. Cotton or rayon. Semi-metallic. Plastic (loose fill). Mechanical seals.
Gasoline and Oils, Hot	Asbestos. Semi-metallic. Plastic (loose fill). Mechanical seals.
Gasoline and Oils, Cold	Asbestos. Semi-metallic. Plastic (loose fill). Mechanical seals.
Air	Asbestos. Semi-metallic. Plastic (loose fill). Mechanical seals.
Gas	Asbestos. Semi-metallic. Mechanical seals.
Acids and Caustics	Asbestos (blue). Semi-metallic. Plastic (loose fill). Mechanical seals. Teflon.
Ammonia	Asbestos. Semi-metallic. Mechanical seals.

ACKNOWLEDGMENT

The information contained in the tables is published through the courtesy of The Garlock Packing Company, Palmyra, N. Y.

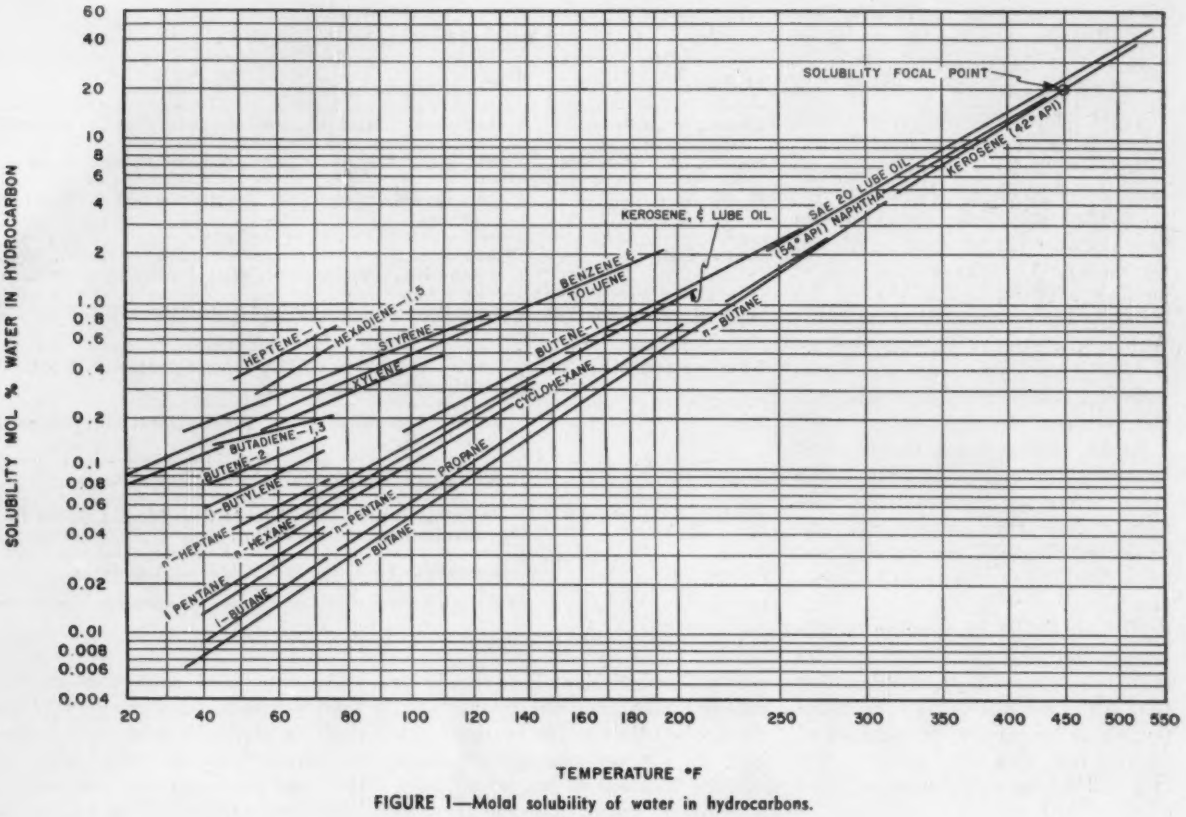

FIGURE 1—Molal solubility of water in hydrocarbons.

How to Predict Solubility Of Water in Hydrocarbons

W. F. Hoot
American Oil Company
Texas City

IN A RECENT article[1] the solubility of water in 17 hydrocarbons and petroleum fractions was presented. It was shown that if the solubility of water, in mole percent, was plotted on a Cox-type vapor pressure plot, a straight line of solubility was obtained for each of the pure hydrocarbons and petroleum fractions. These data are for the saturation of the pure hydrocarbon or petroleum fraction with water at a given temperature under the equilibrium vapor pressure of the coexisting vapor, hydrocarbon and water phases.

A further study shows that extrapolation of these solubility lines indicates a common intersection point similar to the focal point for the vapor pressures of hydrocarbons. This intersection, or focal point, of the solubility lines is estimated to be 450 F. and 20 mole percent water in hydrocarbon. Such a focal point is useful in the extrapolation of limited solubility data. For example, the solubility line for a pure hydrocarbon or petroleum fraction can be estimated by drawing a line through the solubility focal point and one experimentally determined solubility point. This is shown clearly in Figure 1.

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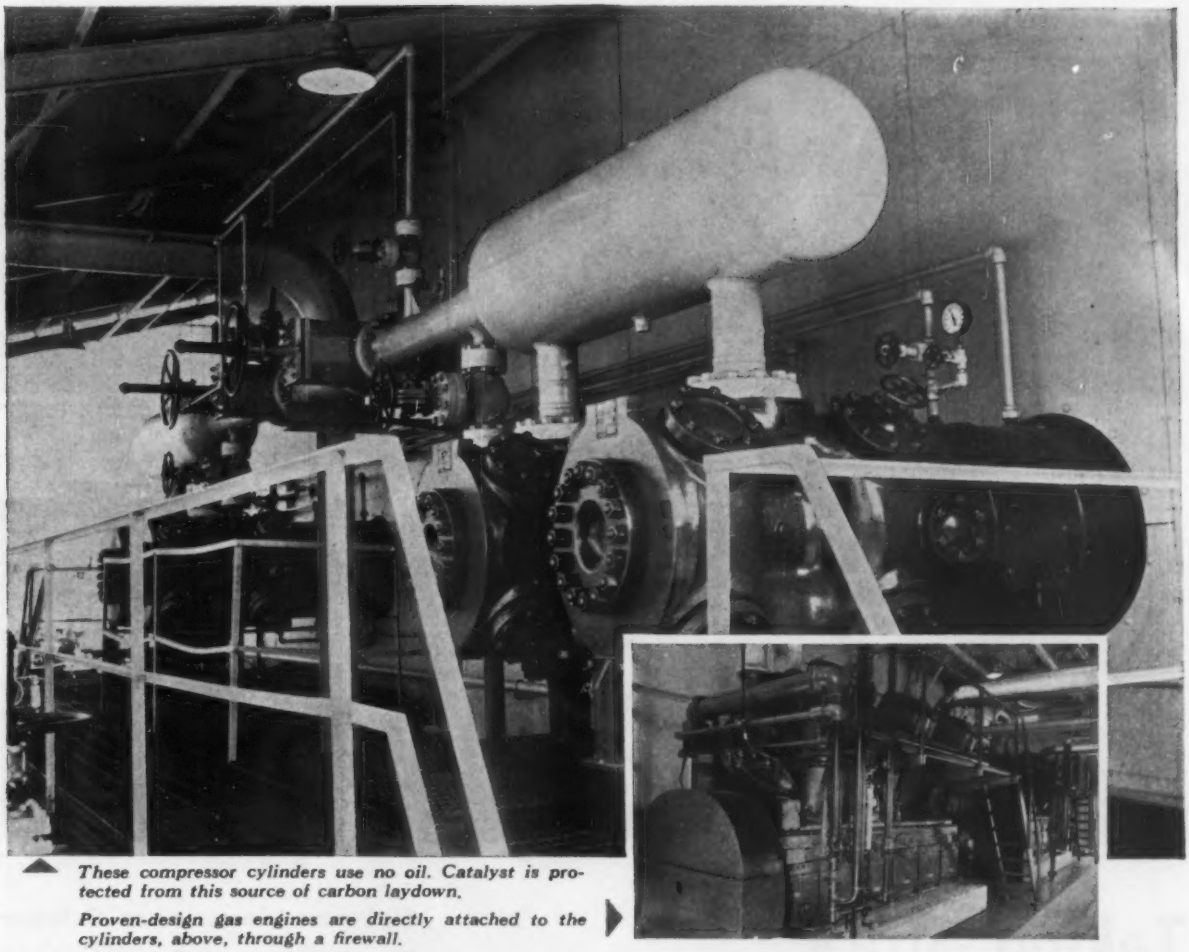
About the Author

W. F. HOOT is with the American Oil Co., Texas City, where he has spent four years in petroleum refinery process design and two years in pilot plant work. His other experience includes 18 months in petrochemical process design with Ethyl Corp., and wartime service as a Navy petroleum inspector. Dr. Hoot received his B.S., his M.S., and his Ph.D. degrees in chemical engineering from the University of Texas.



These compressor cylinders use no oil. Catalyst is protected from this source of carbon laydown.

Proven-design gas engines are directly attached to the cylinders, above, through a firewall.

CATALYST LASTS LONGER

with NL compressor cylinders

No oil to carry over in the recycle gas

One feature of the Platforming process, developed and designed by Universal Oil Products Company, is long catalyst life without regeneration. That means a low catalyst cost per barrel of high-octane gasoline. That's why Skelly Oil Company's Platformer at El Dorado, Kansas, uses Ingersoll-Rand compressors with 'NL' non-lubricated cylinders.

In NL cylinders there is no oil to carry over in the recycle gas into the catalyst-packed reactor. Presence of oil would result in carbon laydown (coating which renders catalyst inactive). Oil also causes excessive hydrocracking and formation of undesirable polymers.

The pistons of NL cylinders are supported by graphitic carbon rings sliding in a mirror-smooth bore. Operation is dependable without oil lubrication.

Cylinders are connected to the gas-engine frame by special two-compartment distance pieces that are sealed and vented to allow safe handling of the hydrogen-laden gas.

The two 660-hp KVG compressors handle a total of 73 million cubic feet of gas a day, boosting pressure from 450 psi to 610 psi. Using available gas, their four-cycle, V-angle engines produce low-cost power at all loads.

Ask your I-R representative for complete information on Ingersoll-Rand gas-engine compressors and non-lubricated compressor cylinders. Obviously standard oil-lubricated compressors should be used wherever possible to reduce first cost and maintenance.

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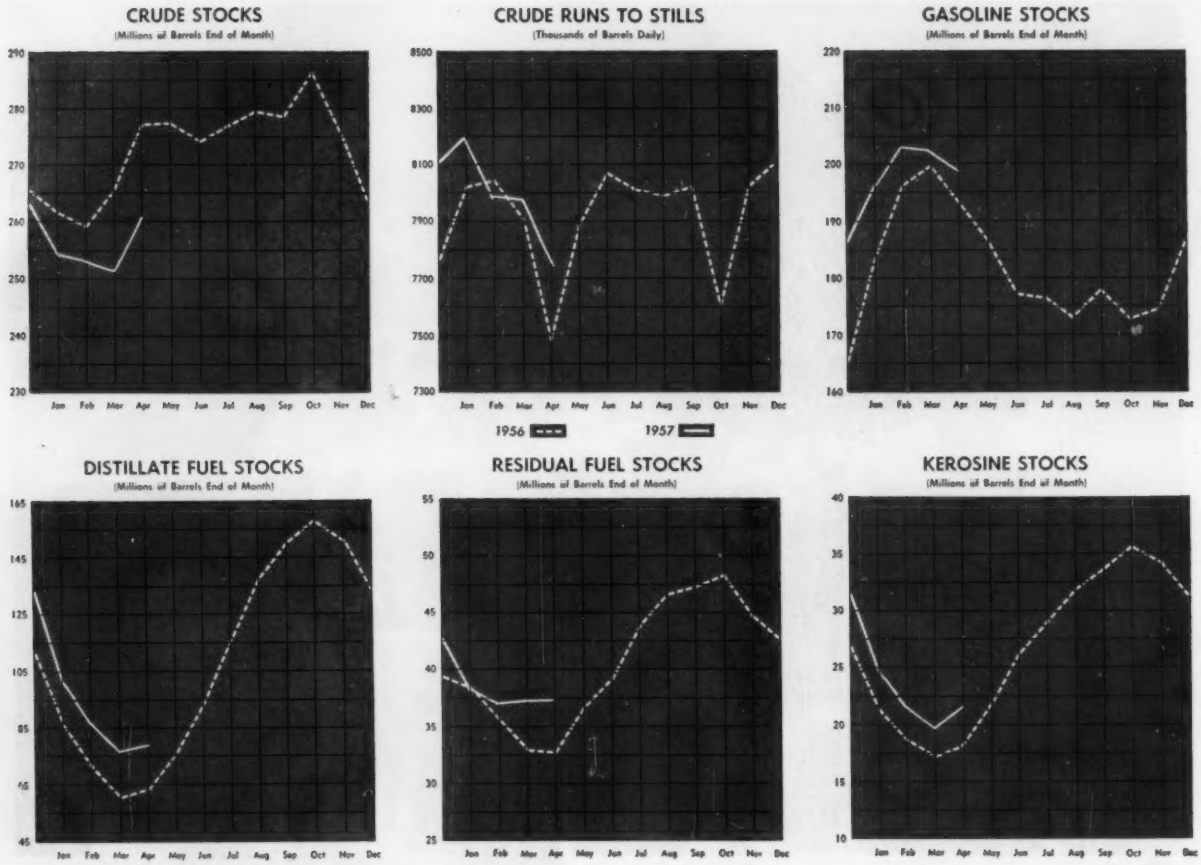

CRUDE STOCKS
(Millions of Barrels End of Month)
CRUDE RUNS TO STILLS
(Thousands of Barrels Daily)
GASOLINE STOCKS
(Millions of Barrels End of Month)
1956
1957
DISTILLATE FUEL STOCKS
(Millions of Barrels End of Month)
RESIDUAL FUEL STOCKS
(Millions of Barrels End of Month)
KEROSINE STOCKS
(Millions of Barrels End of Month)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Taking Stock

Cecil W. Smith
Economics Editor

Still runs lowest since October
Gasoline output & stocks high
Fuel oil stocks start to climb

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1955:													
April	6,887	7,136	275,232	3,502	175,601	312	21,486	1,534	70,139	1,110	43,838	697	1,125
May	6,677	7,281	276,948	3,605	168,751	296	26,375	1,519	83,559	1,111	45,083	742	1,137
June	6,613	7,484	270,850	3,725	157,439	269	29,830	1,628	100,652	1,080	44,398	764	1,159
July	6,632	7,580	264,601	3,824	157,079	286	32,749	1,575	119,169	1,091	44,894	860	1,161
August	6,665	7,580	256,427	3,858	151,912	290	35,292	1,621	133,675	1,090	45,480	756	1,155
September	6,731	7,483	256,269	3,784	150,194	279	36,361	1,621	143,248	1,061	46,267	829	1,218
October	6,837	7,465	267,346	3,827	153,103	309	36,705	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	341	33,283	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	395	26,770	1,765	111,333	1,286	39,174	884	1,502
1956:													
January	7,199	8,023	261,592	3,927	183,905	385	21,310	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	385	18,712	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	342	17,215	1,808	60,846	1,213	32,984	934	1,425
April	7,146	7,487	277,121	3,646	193,299	299	18,227	1,713	63,571	1,130	32,740	815	1,305
May	7,064	7,896	277,497	3,859	186,673	292	21,883	1,667	75,928	1,149	36,607	938	1,416
June	7,100	8,071	274,491	3,976	177,076	290	26,111	1,755	93,758	1,098	39,073	987	1,426
July	7,090	8,014	277,008	3,975	176,536	296	28,990	1,767	115,787	1,066	43,958	1,084	1,463
August	7,195	7,995	279,944	4,037	172,939	313	31,826	1,839	137,905	1,091	46,617	1,001	1,399
September	7,054	8,024	278,791	3,991	177,974	329	33,588	1,845	150,411	1,062	47,342	1,043	1,452
October	6,966	7,608	286,560	3,773	172,798	356	35,667	1,772	158,871	1,082	48,400	1,004	1,541
November	7,139	8,031	275,995	3,913	174,808	384	34,329	1,841	151,517	1,182	44,590	871	1,362
December	7,377	8,141	266,014	4,039	187,271	379	31,420	1,981	133,981	1,288	44,491	873	1,471
1957:													
January	7,480	8,274	256,669	3,991	197,702	367	24,019	2,118	100,572	1,322	38,403	805	1,425
February	7,682	8,088	256,344	3,864	205,270	353	21,013	2,035	85,105	1,270	31,201	780	1,430
March	7,784	8,042	252,313	3,704	203,412	325	19,980	1,856	75,615	1,219	37,311	860	1,457
April	7,525	7,738	261,505	3,743	198,872	283	20,878	1,757	77,913	1,164	37,350	903	1,462
Week Ended:													
5-24-57	7,457	7,910	265,461	3,872	194,373	268	23,935	1,799	91,532	1,083	39,791	1,026	1,424
5-25-56	7,071	7,797	278,136	3,664	183,510	252	20,699	1,732	72,027	1,149	34,787	975	1,408

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

Another satisfied user of Crane Diaphragm valves

Best by test for this heavy, sticky emulsion —Crane diaphragm valves

What valve is best and lasts longest in this service? A West Coast emulsified asphalt producer tried them all on the manifold above and here's what was found.

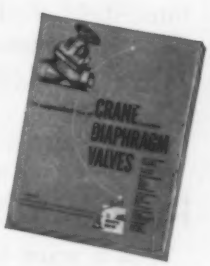
Conventional valves would become inoperative in a short time. The main trouble was binding of the stem in contact with the cold, heavy asphalt emulsion.

Ordinary diaphragm valves on the same service lasted only two months and had to be replaced. The diaphragms didn't stand up and the high torque required for closure was impractical for frequent operation.

Three years ago the plant started using Crane No. 1610 Packless Diaphragm Valves. The neoprene diaphragm functions only to seal the bonnet. It is not subject to crushing and excessive wear as a seating member. The separate disc in combination with Crane Y-pattern body makes positive closure with minimum torque and turns. These valves are giving full satisfaction.

Literature on Request

Wide choice of body and diaphragm materials makes these exclusive Crane valves particularly useful to process industries. Ask your Crane Representative for Circular AD-1942, or write to address below.



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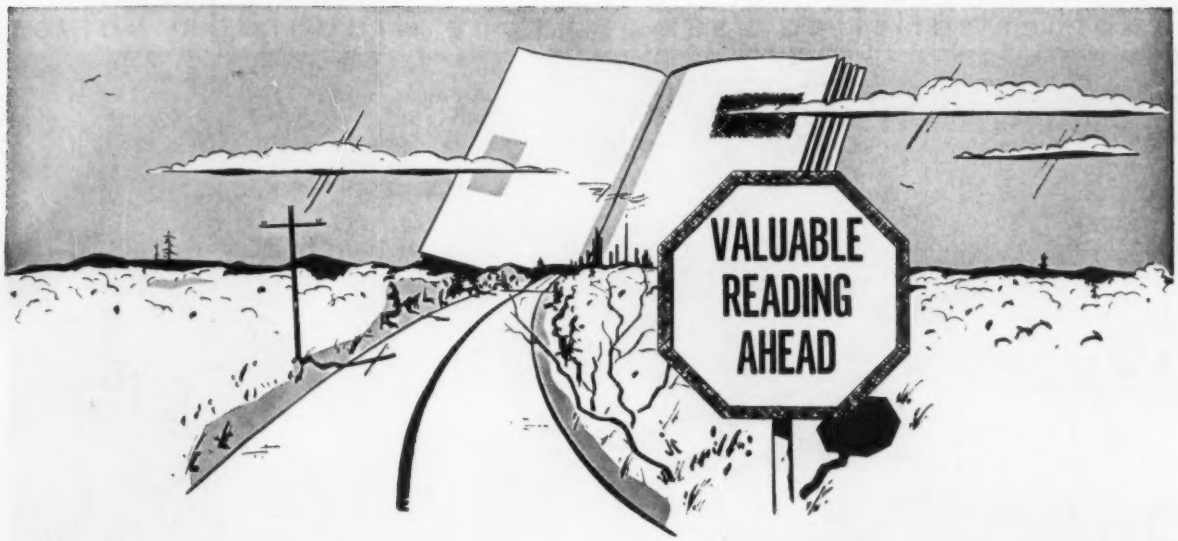


Metal Inspector's Ally

No longer is the X-ray machine found solely in the medical department at Esso's Bayonne refinery. Now days it's being used as an extremely valuable ally to all metal inspectors. You'll get the full details on this interesting procedure and see pictures of how the operation works when you read this month's "How To Do It."

Keep Going to Page 204

Who's Building?

The answer to this question is ready and waiting for you in this month's section of "Who's Building." More than three dozen construction items are presented in capsule form so that you can get the maximum information in the shortest time. There's also an interesting lead story about the new plant Shell Petroleum is developing in Shell Haven, England. It's all there to read so . . .

Keep Going to Page 211

Process Plant Engineering

You'll want to read the review of the new book "Project Engineering of Process Plants" by H. F. Rase and M. H. Barrow. This is the first book to recognize the new profession and to formulize the methods of executing a project used by all progressive chemical companies and engineering firms.

Keep Going to Page 264

14-Year Secret Told

An oil company has taken the wraps off a World War II secret by revealing the part it played in developing the first atomic bomb. Only now, however, has information on the secret project—known as No. 4 process laboratory—been declassified by the Atomic Energy Commission. Read this highly interesting story that's headlined this month in "What's Happening in the Industry."

Keep Going to Page 251

What, Where and When

A "reading must" for every man in the industry is Petroleum Refiner's "Meetings Calendar." It's an easy-to-read tabulation of what's coming up in the societies and associations that are of most interest to you.

Keep Going to Page 263

Here's What's New

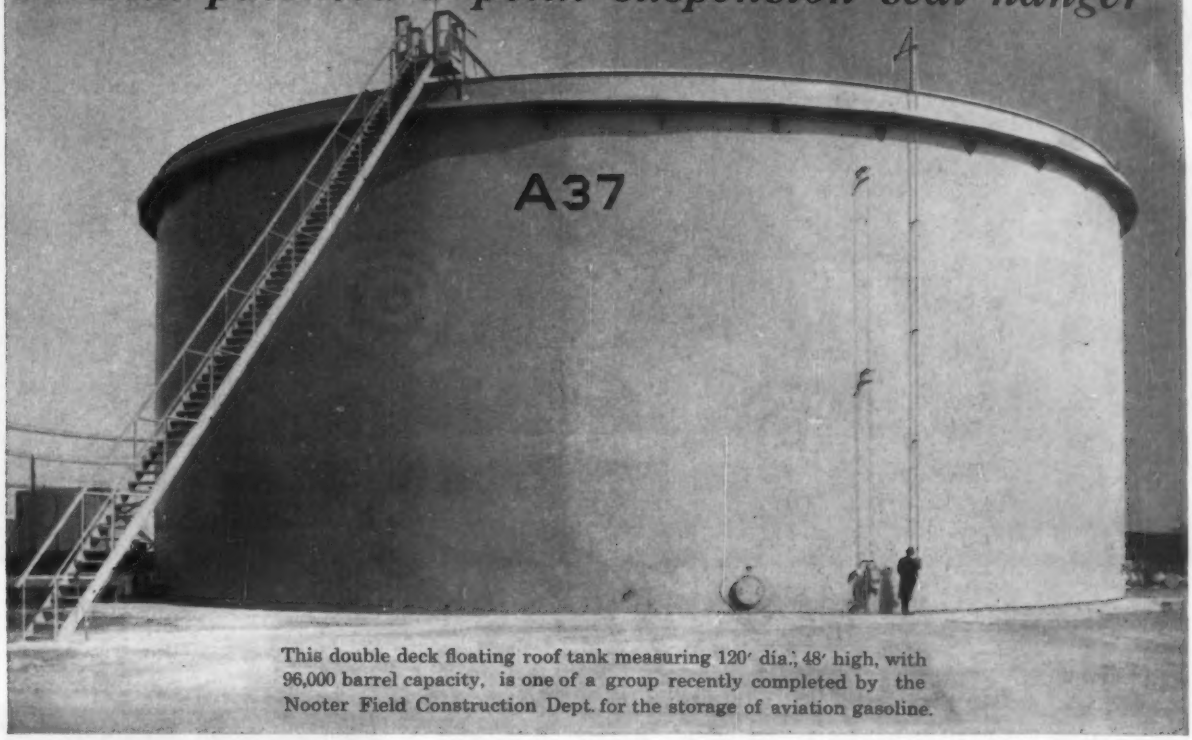
Yes, this month, and every month, PETROLEUM REFINER presents a run-down on new equipment we think you'll be interested in. As a "for instance," read about the "first" that has been credited to stainless steel with the completion of a stainless lining for a two million gallon reservoir. There's also the opportunity to use the handy Readers' Service Card to get free information about any of the items in this section. Keep up with the times, read "What's New in Equipment and Manufacturers Literature."

Keep Going to Page 312

NOOTER announces...

new floating roof tank

with patented 2-point suspension seal hanger



This double deck floating roof tank measuring 120′ dia., 48′ high, with 96,000 barrel capacity, is one of a group recently completed by the Nooter Field Construction Dept. for the storage of aviation gasoline.

The floating roof oil and gasoline storage tanks fabricated and erected by Nooter are now distinguished by the new patented Nooter seal.

Because this seal exerts a uniform outward pressure over the entire height of the sealing shoe, a better seal is achieved, and abrasion at any one point is reduced.

Another important feature of the seal: all operating mechanism is placed beneath the roof, leaving the deck clear and neat.

The Nooter seal is adaptable, without size limitation, to double-deck, pontoon and pan-type roofs, or any existing type of floating roof.

For complete information on how the new Nooter floating roof tank can serve you better, write or call Nooter today. No obligation.

new NOOTER SEAL design offers you:

- A simpler, more effective seal.
- Faster installation.
- Better radial alignment.
- Uniform outward pressure, less wear.
- Lower storage loss.

Write for PLANT SURVEY REPORT No. 4
for a comprehensive report on NOOTER facilities.

NOOTER CORPORATION

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Steel and Alloy Plate Fabricators and Erectors..."Boilermakers"

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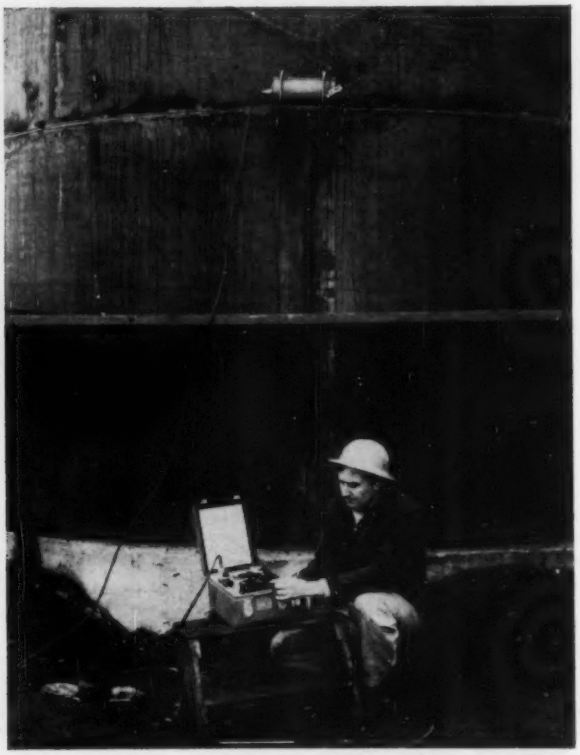
How To Do It . . .



X-Ray machine is set-up . . . to take remote controlled photos

Here's an X-ray Machine That's a Metal Inspector's Ally

No longer is an X-ray machine to be found solely in the medical department. These days the X-ray machine is used almost anywhere in Esso's Bayonne refinery and the machine is a valuable ally to the metal inspectors. Checking welds on tanks is a very exacting task since one little flaw could mean a leak which might eventually split a seam. The photos show inspectors using X-ray to check the asphalt plant tanks which are being erected. The top left photo shows the machine being set-up. When the picture is actually being snapped, the operator must stand at least 15 feet away and operate the machine from a control box (top right). After a minute and a half, one of the operators enters the tank and removes the film (right).

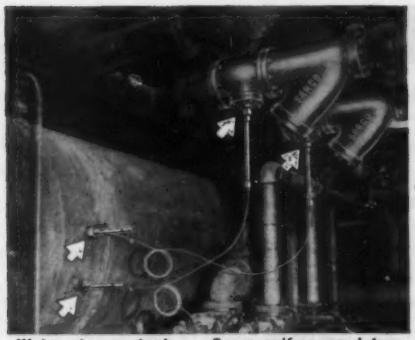
Metal inspectors also use X-ray to detect internal pitting in piping systems and external corrosion in boiler tubes. The machine shown here will penetrate one and one half inches of steel.

Story and photographs courtesy *Esso Bayonne News.*

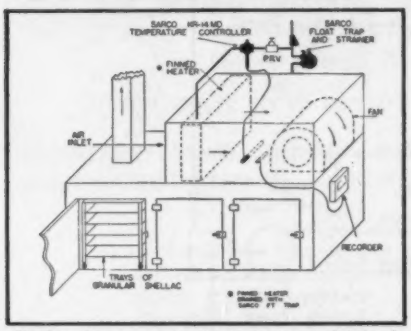
. . . then operator removes film

Calculate Boiler Horsepower

To find the actual boiler horsepower being produced, mark off two places from the number of gallons

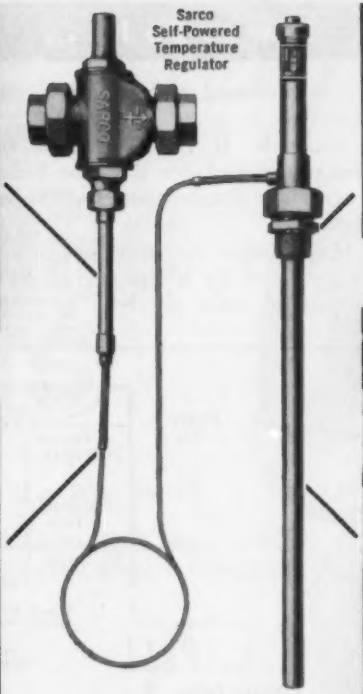


Water storage tanks — Sarco self-powered temperature controls on service water storage tanks from twin heaters.



Shellac dryer — even temperature maintained; moisture uniformity of granular shellac accurately controlled — by Sarco self-powered temperature control.

Sarco Self-Powered Temperature Regulator



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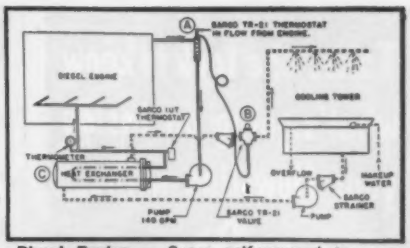


Diesel Engine — Sarco self-powered temperature controller used on diesel engine cooling system. Also ideal for compressors.

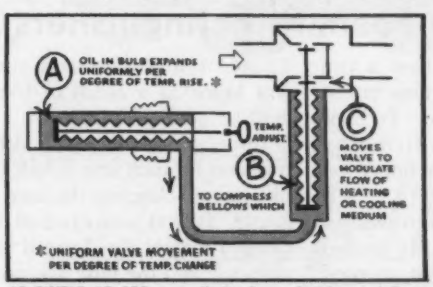
Steam-jacketed kettle — desired temperature of kettle content is automatically maintained by Sarco self-powered temperature control. Steam waste, uncertainty of manual control eliminated.

How to get Automatic Temp. Control that's simple, dependable, inexpensive

HERE'S the way to get rid of uncertain, time-wasting manual temperature control . . . *throughout* your plant. And without investing in complicated, costly temperature control equipment.

These SELF-POWERED Sarco controls are inexpensive, simple, dependable, accurate. They can be used for 85% of your jobs. ½" size costs only about $100!

Thousands of these Sarco controls are giving dependable, accurate service for firms such as Colgate-Palmolive Co., Sinclair Refining Co., Swift and Co.


A
OIL IN BULB EXPANDS UNIFORMLY PER DEGREE OF TEMP. RISE. *
TEMP. ADJUST.
C
MOVES VALVE TO MODULATE FLOW OF HEATING OR COOLING MEDIUM
B
TO COMPRESS BELLOWS WHICH
* UNIFORM VALVE MOVEMENT PER DEGREE OF TEMP. CHANGE

AS SIMPLE AS ABC . . . that's Sarco Self-Powered Temperature Control. A thermostat with capillary tubing and a valve . . . that's all there is to it!

SARCO SELF-POWERED TEMPERATURE CONTROLLERS
—need no power source

1. Self-Powered — no compressed air or electricity needed.
2. Easy to install — by any pipe-fitter.
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SARCO

Automatic Temperature Control

ELECTRIC INDICATING AND SELF-POWERED TEMPERATURE CONTROLLERS • STEAM TRAPS • STRAINERS

Takes one look to know what's going on inside your flow line with...

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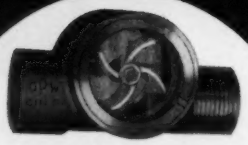
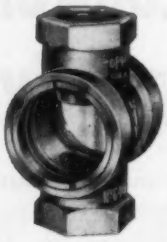


No. 44

No. 444



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OPW VISI-FLO sight glass indicators are a trustworthy visible means of alerting you as to rate of flow, viscosity, color of liquids, clarity, and purity of product.

OPW VISI-FLO protects you against line stoppage, helps maintain uniformity, a high standard of product quality and an even continuity of production.

WRITE FOR FREE BULLETIN F-6 describing complete VISI-FLO line, from plain types to magnetic indicating types.

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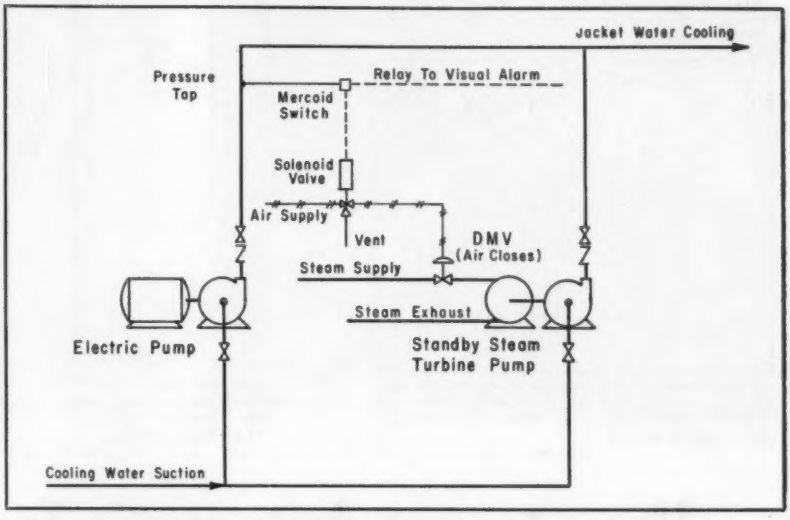
How to Do It...

being processed and you have the number.

Example: If 420,000 gallons are being processed per day, the boiler horsepower is approximately 4200 per day.

Explanation: A boiler horsepower is produced by evaporating 34.5 pounds of water per hour into dry and saturated steam at 212 F. Thus, 34.5 pounds of water per hour divided by 8.33 pounds per gallon equals 4.1416 gallons per hour, or 99.4 gallons for a 24 hour period. This ratio is approximately 100, which is the rule of thumb digit for obtaining boiler horsepower.

Idea submitted by:
Rudell Russell
Bell Oil and Gas Company,
Grandfield, Okla.



Automatic Controls Start Standby Pump

A DMV control, actuated by a solenoid valve and a mercoid switch, has been installed on the standby steam turbine pump used for supplying cooling water to the cat cracker gas compressors at this Phillips, Texas refinery.

In case of failure of the electric cooling water pump, the pressure drop in the discharge opens the circuit on a mercoid switch, which trips the solenoid valve, thereby shutting off the air supply to the DMV, which opens the steam supply to the standby steam turbine pump. Thus, the standby pump is started automatically and there is no interruption of cooling water supplied to the compressors during power failures. This hook-up has saved considerable compressor maintenance by eliminating the time lag for manually starting the standby turbine pump.

Idea submitted by L. J. Smith, Phillips refinery, Phillips, Texas.

Safety First for Foamite Extinguishers

Here's a true story of how a two and one-half gallon foamite extinguisher killed a fire fighter. It happened in the drum reconditioning plant of the Kaohsiung refinery on Formosa.

Spillage from a used drum was ignited by a welders torch. He picked up the nearest extinguisher, turned it upside down but nothing came out. He shook it vigorously, cautiously eyeing the fire. Suddenly there was a violent explosion and the welder was killed as a result of the schrapnel-like bombardment.

Inspection of the extinguisher parts revealed an inch and a half of chalk-like matter clogging the hose near the nozzle. It was concluded that the clogged matter was formed after previous use and the hose was not flushed with water. Thus, the following rules were adopted:

- All classes of foamite extinguish-

JEFFERSON

GAS-SCRUBBING AGENTS

. . . are ready to roll by tank car or tank wagon from nearby shipping points.

MONOETHANOLAMINE **DIETHYLENE GLYCOL**
DIETHANOLAMINE **TRIETHYLENE GLYCOL**

for:

Natural Gas Sweetening
Refinery Stream Sweetening
Sulfur Recovery
Gas Dehydration
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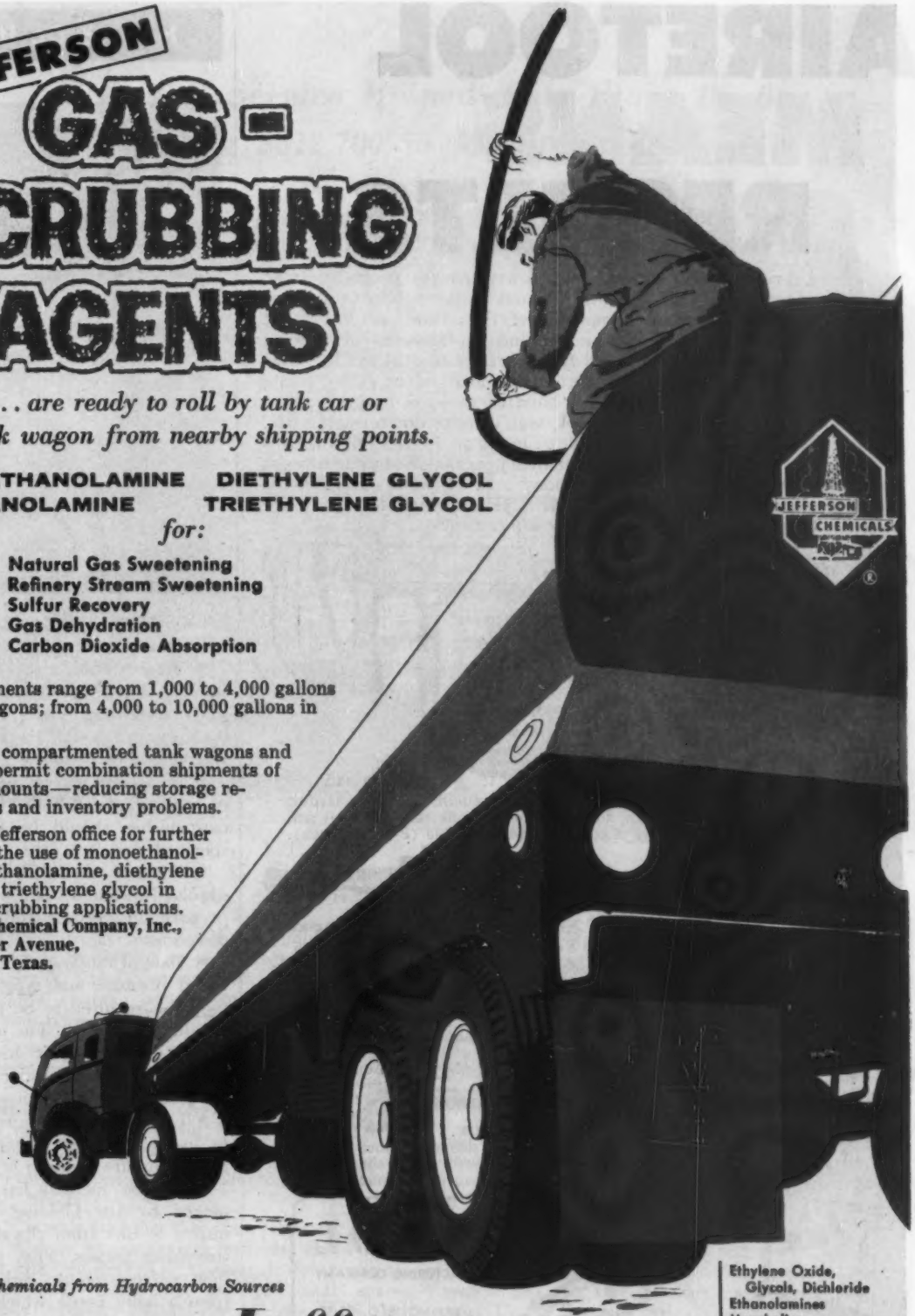
Bulk shipments range from 1,000 to 4,000 gallons in tank wagons; from 4,000 to 10,000 gallons in tank cars.

Jefferson's compartmented tank wagons and tank cars permit combination shipments of smaller amounts—reducing storage requirements and inventory problems.

Call your Jefferson office for further details on the use of monoethanolamine, diethanolamine, diethylene glycol and triethylene glycol in your gas-scrubbing applications.
Jefferson Chemical Company, Inc., 1121 Walker Avenue, Houston 2, Texas.



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CHEMICAL COMPANY, INC.

HOUSTON • NEW YORK • CHICAGO • CLEVELAND • CHARLOTTE • LOS ANGELES

Ethylene Oxide, Glycols, Dichloride
Ethanolamines
Morpholine
Piperazine
Polyethylene Glycols
Nonyl Phenol
Surfonic® Surface-Active Agents—N Series and TD Series
Ethylene Carbonate and Propylene Carbonate

For more data on advertised products, use Readers' Service Cards, last page.

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. . . results you can *measure* in lower operating costs, reduced down-time, greater efficiency and higher production. Plant engineers and maintenance chiefs the nation over *know* that installation, repair, removal and replacement of tubular equipment is completed faster, easier and at far less cost with Airetool Tube Maintenance Equipment. They know that Airetool Equipment handles easy, is rugged, packs plenty of power and speed, won't break down during use. There's no doubt about it . . . insist on AIRETOOL Equipment for your tube maintenance program. See your nearest Airetool Representative today . . . or write AIRETOOL MANUFACTURING COMPANY, Springfield, Ohio, for free illustrated literature and information.

DESCRIBED ON PAGE 15

CONDENSER CLEANERS
Outside mounted, direct or gear driven. Powerful, fast, lightweight (11 lbs.). Cleans lightly scaled or completely plugged tubes to 1". Built in flushing system cools drill, removes chips.

MORE ON PAGE 5

TUBE CLEANERS
Rugged, fast cutting, quickly and thoroughly removes hardest scale and deposit. Air driven motors in wide range of sizes and speeds. Wide variety of cleaner heads available (P-type shown).

SEE PAGE 18

CONDENSER TUBE EXPANDERS
Parallel rolling—self feeding—Airetool Tube Expanders roll right, accurate tube joints with maximum bond, uniform expansion and tightness throughout full thickness of tube sheet.

READ PAGE 16

INTERNAL TUBE CUTTER
New . . . removes leaky or damaged tubes in minutes. Cuts steel or non-ferrous tube sheets 1" to 4" thick. Air or electric driven motor.

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Write for illustrated Airetool Bulletin No. 60, showing complete line of Airetool Tube Maintenance equipment plus Airetool Specialty tools . . . Airetool's new, light-weight, air-motor grinders . . . and Airetool's Automatic Expansion Control System.

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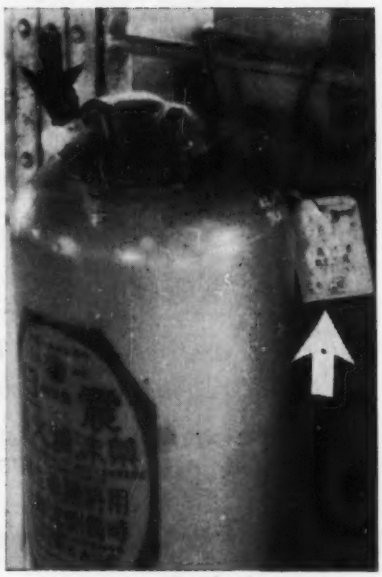
How to Do It . . .



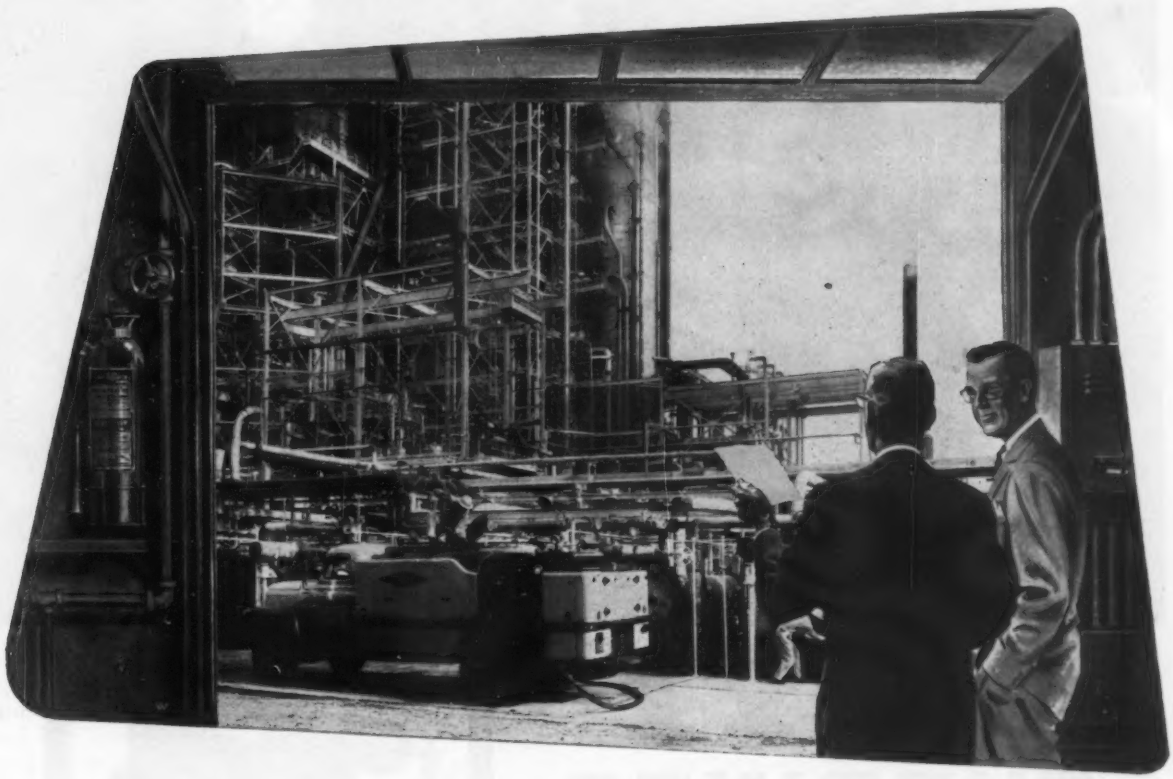
ers should be refilled with fresh solution at the interval of one year.

- Before refilling the outside and inside cylinder, nozzle and spray hose must be thoroughly cleaned. Also, the spray path should be checked for freedom of dirty substances.
- In accordance with the interval of refilling, the cylinder body of the extinguisher should be tested to a specified pressure.
- Powders should be completely dissolved in water. The procedure of preparation must carefully follow the directions.
- Date of refilling, expiration date, tested pressure and type of powder used are required to be punched on an aluminum plate. The plate (white arrow in picture) is hung on the handle or on the shoulder of the bottle after the extinguisher is refilled.
- Local supervisors are expected to make a monthly inspection of their own fire fighting equipment.

A unique method has been employed by the Chinese to prevent insects or dirt from clogging the extinguisher nozzles. They use a common narrow-mouth, rubber nipple from a baby bottle which is slipped over the nozzle (black arrow).

Idea submitted by:
Tzen-Yung Yang,
Kaohsiung, Refinery,
Chinese Petroleum Corp.,
Kaohsiung, Taiwan
(Formosa).

Dowell Service Helped This Plant Profit By Saving $312,700 in Maintenance Costs!



To clean and service the giant catalytic crackers in today's modern refineries is quite a job . . . and very costly. Costly, that is, unless Dowell Service is on the job to help clean the "cats"—chemically. Here's an example of how Dowell chemical cleaning service cut turnaround costs for one refiner by $312,700.

Dowell was called in to provide cat cracker turnaround service which included the cleaning of: two flue gas coolers, two catalyst coolers, four overhead aftercoolers, one light gas oil cooler, one heavy gas oil cooler, two top tray reflux coolers, and two final gas condensers.

Dowell's time: thirteen and one-half hours; Cost: $2300.

It is estimated that this same cat cracker service, if done by mechanical methods, would have cost the refinery: 1) Additional downtime of seven days—$210,000; 2) Additional spare bundle inventory—$100,000; 3) Labor—$5,000.

The refinery enjoyed a $312,700 operating credit from this single cat cracker turnaround—not including expected efficiency increases.

Dowell provides expert service in removing scale and sludge from product, process and steam generating systems. Dowell does the job for you—furnishing all chemical solvents, trained personnel, pumping and control equipment. Furthermore, Dowell has the experience in chemical cleaning to provide assurance of a job well done.

While the example here deals with an oil refinery, Dowell chemical cleaning has recorded similar profit-making savings for other industries. Dowell engineers can show you performance data in almost any field — steel, chemical, power, paper, construction.

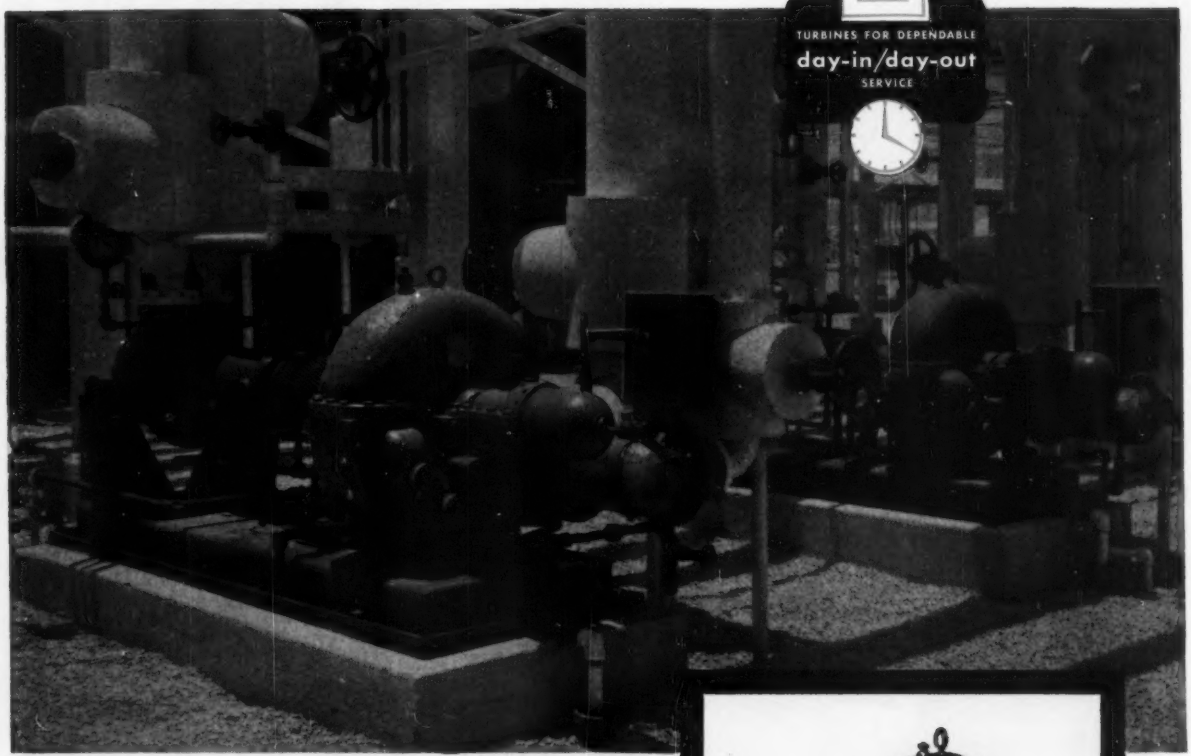
For specific information on how Dowell chemical cleaning can help your plant to greater profits, call the Dowell office nearest you. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

have Dowell clean it chemically

DOWELL

A SUBSIDIARY OF THE DOW CHEMICAL COMPANY

For more data on advertised products, use Readers' Service Cards, last page.



ELLIOTT YR TURBINES

the best anywhere...serving process industries everywhere

There's no mystery behind the popularity of Elliott YR turbines. They are deliberately designed to provide the highest quality, long-term continuous service. Turbine components are made of the finest materials, built in quantity to close tolerances and rigid specifications. Assembly is carefully controlled to meet the required—and in fact the most rugged—operating conditions. Easy inspection, accessibility of wearing parts and interchangeable components are additional advantages.

That's why thousands of Elliott mechanical drive turbines are in use all over the country—like the two above, driving a natural gas plant pump in West Texas. For Bulletin H-22B which describes the designing features, call your local Elliott field engineer or write Elliott Company, Steam Turbine Division, Jeannette, Pa.

6 design features you get with ELLIOTT YR single-stage turbines

- True Centerline Support for precise alignment, cold or hot, simplifies installation.
- Weather-Proofed, Reliable Governing System with separate overspeed trip and valve.
- Liner Type Bearings, easy to inspect or replace, rapid heat transfer to cooling oil, sealed against elements.
- Accessible Shaft Seals. Covers—not part of turbine casing—are easily removed for inspection or ring replacement.
- Self-Locating Rotor drops into position without adjustments. Entire rotor is dynamically balanced.
- Interchangeable Components permit interchanging of parts between turbine frame sizes, eliminates need for large inventories.

H7-2

ELLIOTT Company

Steam Turbines • Motors • Generators • Deaerating Heaters • Ejectors • Condensers • Centrifugal Compressors • Turbochargers • Tube Cleaners • Strainers

Who's Building . . .

Next Construction BOXSCORE appears in July issue

Shell to Use New Synthesis Gas Process

New process can use gas or the heaviest fuel as raw material for ammonia production.

Shell Petroleum is now developing a new plant at Shell Haven, England, for the production of ammonia, nitric acid and ammonium nitrate, a granulated fertilizer.

Cost of this new plant is estimated at over $17 million and it is an expansion of Shell Petroleum's activities in agricultural chemicals.

The production of ammonia at this plant will be by a process recently developed by Shell, based on fuel oil gasification. This is a partial combustion process operated under pressure and using oxygen or oxygen-enriched air, by which any feedstock ranging from gaseous hydrocarbons to the heaviest fuel oil can be converted into crude synthesis gas containing a high percentage of hydrogen and carbon monoxide.

Novel features of this process include the efficient recovery of waste heat from the gas by way of high pressure steam generation and the removal from the synthesis gas of a small quantity of carbon in a form which makes it suitable for further use. The first unit employing this process came into successful operation at Ijmuiden in December, 1956.

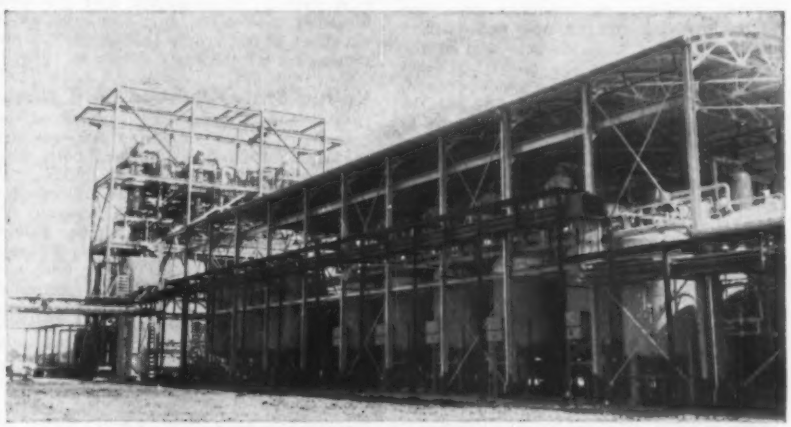
By the use of this process at Shell Haven, it will be possible to insure that the production of ammonia will be based on the most economic feedstock regardless of which petroleum fractions are most cheaply available at the refinery.

The remainder of the ammonia plant will be of more conventional design and will include units for the removal of hydrogen sulphide by the Shell phosphate process, for the shift conversion of carbon monoxide to hydrogen, for the removal of carbon dioxide by the hot potassium carbonate process, for the final purification of the synthesis gas by a wash with liquid nitrogen, and for the synthesis of ammonia.

Some of the ammonia will be further processed to nitric acid. After making a study of the economics of operating under various conditions, it was decided that a plant operating at medium pressure, producing an acid of about 57 percent concentration, would be the one most suited.

For the production of granulated ammonium nitrate fertilizer, the first step is to produce a highly concentrated slurry of ammonium nitrate by the neutralization of nitric acid with gaseous ammonia. Powered chalk is then added to the slurry after which the mixture enters the granulating drums. The last stage is sieving, to insure the production of a material having the right size range, followed by cooling. By maintaining the ratio of ammonium nitrate to chalk at about 59 to 41, a material is produced which is a physical mixture of ammonium nitrate and chalk and which has a nitrogen content of at least 20.5 percent.

The Shell Haven fertilizer plant is not due to start up until the end of 1958 but the British market for ammonium nitrate fertilizer is being developed by importing an ammonium nitrate/lime fertilizer with a minimum nitrogen content of 20.5 percent from the Netherlands.



Two lines of reactors form the heart of the expansion which gives Goodyear Tire and Rubber Co's Houston synthetic rubber plant a 50 percent increase in capacity. Each line contains 11 reactors of 5000 gallon capacity. The recovery area, consisting of three new stripping columns, rises above the reactor building.

Goodyear Capacity Hiked by 50 Percent

Completion of an expansion program costing nearly $10 million and which will boost synthetic rubber production capacity at Goodyear Tire and Rubber Co.'s Houston synthetic plant to 220,000 long tons a year was announced by company president E. J. Thomas.

With this 50 percent rated capacity increase, Goodyear's Houston plant

thus becomes the world's largest single producer of dry type synthetic rubbers. Completion of the expansion program comes just two years after purchase of the plant from the Government.

"Indications are that within a few short years world-wide demand for rubber will exceed present supplies and we have moved to beat what could otherwise develop into an acute shortage of this vital material with runaway prices," Thomas said.

Heart of the $10 million expansion was the construction of two completely new reactor lines, each containing 11 reactors of 5000 gallon capacity each, and a new recovery area with three new stripping columns.

Also included in the expansion program are spherical butadiene blend tanks of 210,000 gallon capacity each, which make possible a sevenfold increase in storage capacity of butadiene. Styrene storage capacity also has been increased proportionately.

A new materials preparation building makes possible more efficient use of manpower and will contribute to new economies in plant operation.

Instruments and controls in the expanded facilities are more centralized and allow more accurate control over the production process at every stage.

Another important part of the expansion is a new and larger final process or finishing building containing four drying units, each three stories high. Also included in this building is an additional 37,000 square feet of warehouse storage space.

Warehouse space at Goodyear's Houston synthetic plant now totals more than 117,000 square feet and more than 17 million pounds of rubber can be stored at one time.

Goodyear was the first of the private rubber producers to announce expansion plans involving major new construction after the synthetic plants were sold by the government. During the past two years under Goodyear ownership and operation, the plant has turned out 641,574,518 pounds, or 286,417 long tons of rubber for the rubber industry.

Kerr-McGee Oil Industries has awarded a contract for the design and construction of new facilities for its Wynnewood, Okla., refinery to the Refinery Engineering Co., Tulsa. Engineer-architect on the project is the C. W. Nofsinger Co., Kansas City, Mo.

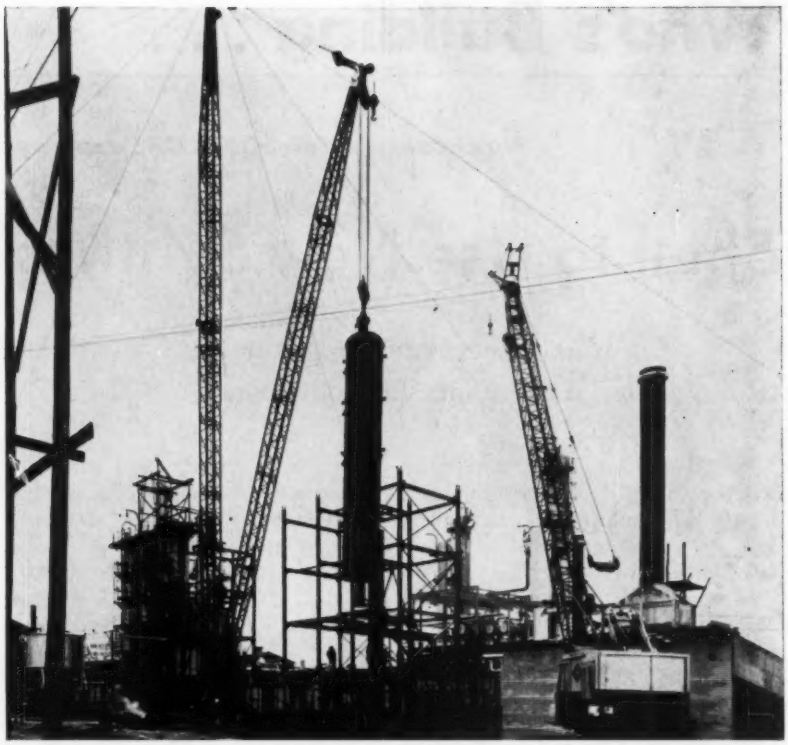
Plant additions will include a 7350-bpd naphtha prefractionator, a 5500-bpd naphtha Unifiner, a 5500-bpd Platformer, and a 4000-bpd distillate Unifiner, together with certain other additions and improvements outside of the process area.

Total value of the additions to the plant is in excess of $4 million.

The Dow Chemical Co. has announced that the construction of a second synthetic glycerine plant is under way at its Texas division, Freeport.

Completion of the new plant, scheduled for next March, will double Dow's present glycerine capacity. Most major equipment has already been delivered.

The second plant, like the first, will use a Dow-developed process involving propylene and chlorine as starting materials. Dow has been producing glycerine at Freeport since June of 1955.



Eighty-three ton reactor is eased into place at Gulf Oil Corp.'s Port Arthur, Texas, propylene polymer plant. Procon Inc., is doing the engineering and construction of the project.

Phillips Petroleum Co. will add to the output of high-octane gasoline from its Woods Cross, Utah, refinery with construction of a 3700-bpd catalytic reforming unit.

A contract to build the unit has been awarded to Procon, Inc. Construction is expected to start early this fall with completion set for the early spring of 1958.

United States Rubber Co.'s Naugatuck Chemical division has announced the completion of one expansion program and the start of another. Cost of both programs will total more than $9 million.

Production of Paracril, an oil-resistant synthetic rubber, has been increased 60 percent at the division's Baton Rouge plant at a cost of approximately $2 million. Also, foundations have been laid, and steel will soon rise, for a new chemical plant on a 150-acre site in the Scotts Bluff area of Baton Rouge. Scheduled to be completed in December, this plant will require a total investment of more than $7 million. It will be used to make Kralastic plastic materials employed in pipe, automotive parts and many industrial products.

The new plant will triple Naugatuck Chemical's production capacity for Kralastic. When completed it will give us the capacity to make more than 60 million pounds of plastic and synthetic rubber yearly in Baton Rouge.

Engineering and construction work for the Paracril expansion was done by Nichols Construction Co., Baton Rouge. Design and engineering for the new plastic plant is being done by Walter Kidde Constructors, Inc. The field construction contract for the plant has been let to Louisiana Industrial Services, Baton Rouge.

Champlin Oil & Refining Co., Fort Worth, Texas, has awarded a contract to Badger Manufacturing Co. for the construction of a 1400 bpd Phillips hydrofluoric acid alkylation unit for its Enid, Okla., refinery. The unit is expected to be completed by March, 1958.

Carbide & Carbon Chemicals Co. has completed a new ethanolamines unit that more than doubles enthanolamines capacity at its Seadrift, Texas, plant.

The additional capacity for ethanolamines now makes it possible for Carbide to supply ethanolamines from two sources —Seadrift, Texas, and South Charleston, W. Va. This expansion also makes it possible to supply more ethanolamine derivatives. Already, Carbide is doubling its capacity for producing morpholine, which is made by dehydrating diethanolamine. Further expansions are to be expected in an integrated pattern of growth.

Monsanto Chemical Co. is beginning an immediate expansion of the capacity of its acrylonitrile plant at Texas City, which will increase its annual output to more than 100 million pounds.

Acrylonitrile is a major raw material in the manufacture of plastics, nitrile rubber and man-made fibers including Acrilan acrylic fiber, which is manufactured by The Chemstrand Corp., Decatur, Ala., a company jointly owned by Monsanto and American Viscose Corp.

Chemstrand recently announced it was rushing to completion a 50 percent increase in its Acrilan production capacity, bringing it to 45 million pounds a year by the first quarter of 1958.

Acrylonitrile is made by combining

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

385 Madison Avenue New York 17, N. Y.

Lummus to Build 200,000,000 lb. per Year Ethylene Plant for Petroleum Chemicals, Inc.

Installation Designed for 50% Expansion

The Lummus Company is presently designing and will build for Petroleum Chemicals, Inc. at Lake Charles, Louisiana a plant to produce 200,000,000 pounds per year of ethylene. Scheduled for completion by the end of 1957, the plant is designed to permit expansion of output to 300,000,000 pounds.

The plant will use Lummus' ethylene process and will draw refinery gases supplemented with LPG from the nearby refineries of Cities Service and Continental Oil, by whom P.C.I. is jointly owned. Ethylene will be made in two grades — the top grade 99.8% pure — the second 98.5%. By-products will be 95% pure propylene, C_4s, and an aromatic distillate.

Cracking section of the plant features an improved Lummus heater which embodies years of research and development by Lummus' Heater Division. Equipment in the Lummus-designed low-temperature fractionation unit includes 12,500-hp gas turbines which drive the centrifugal charge and refrigeration compressors; exhaust from these turbines generates high-pressure steam in three waste heat boilers. The system utilizes high efficiency expanders to recover very low temperature refrigeration.

This plant brings the total of Lummus designed ethylene plants to 14, with a combined capacity of over 3 million pounds per day.

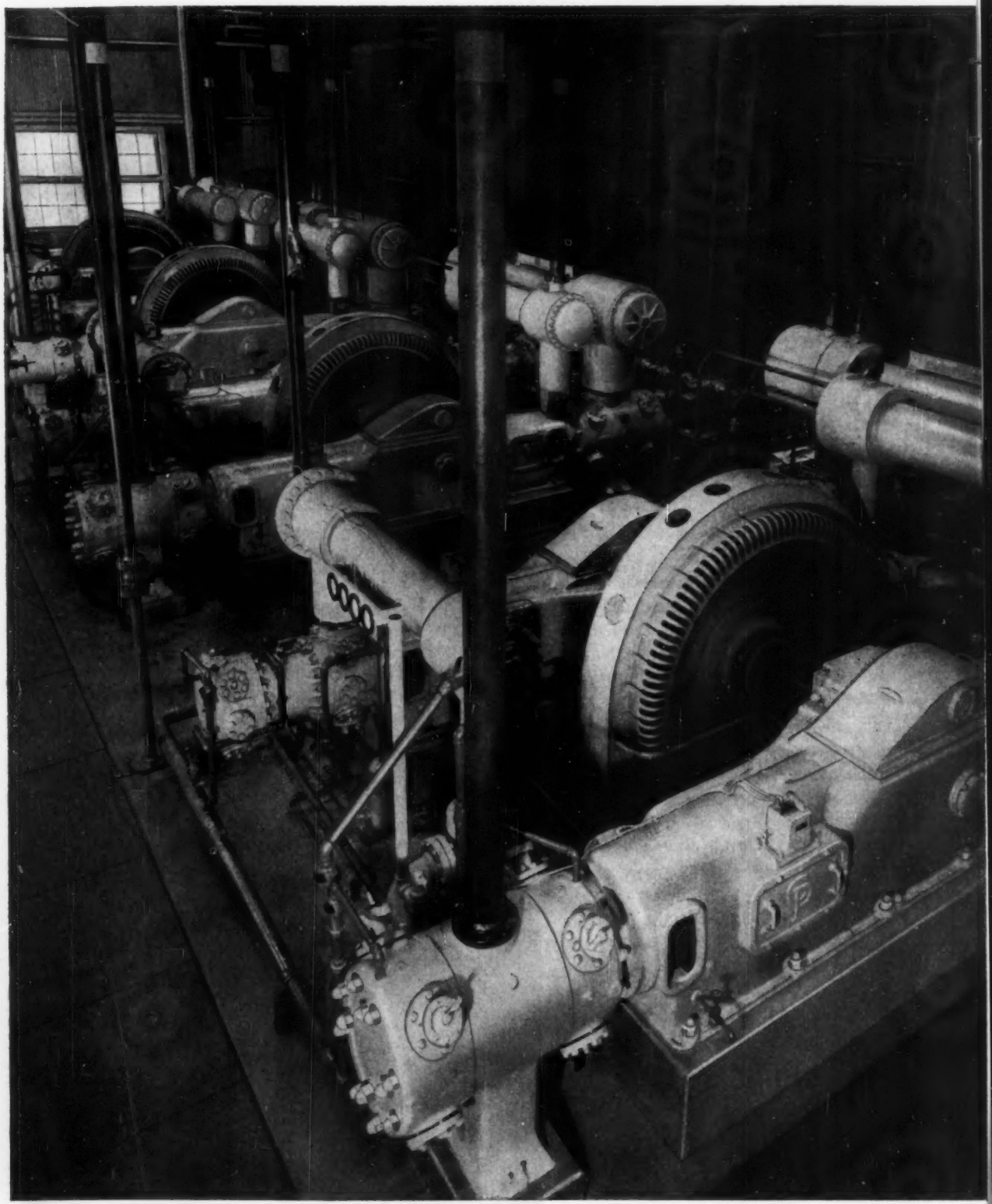
Part of the new plant's ethylene output will be sold to Calcasieu Chemical Corporation, which will use it to produce ethylene oxide and glycol in a plant adjacent to the ethylene unit. Lummus is currently designing and will build the Calcasieu installation.

Lummus has over half a century of experience with chemical and petrochemical projects. Why not discuss your next project with a Lummus representative.

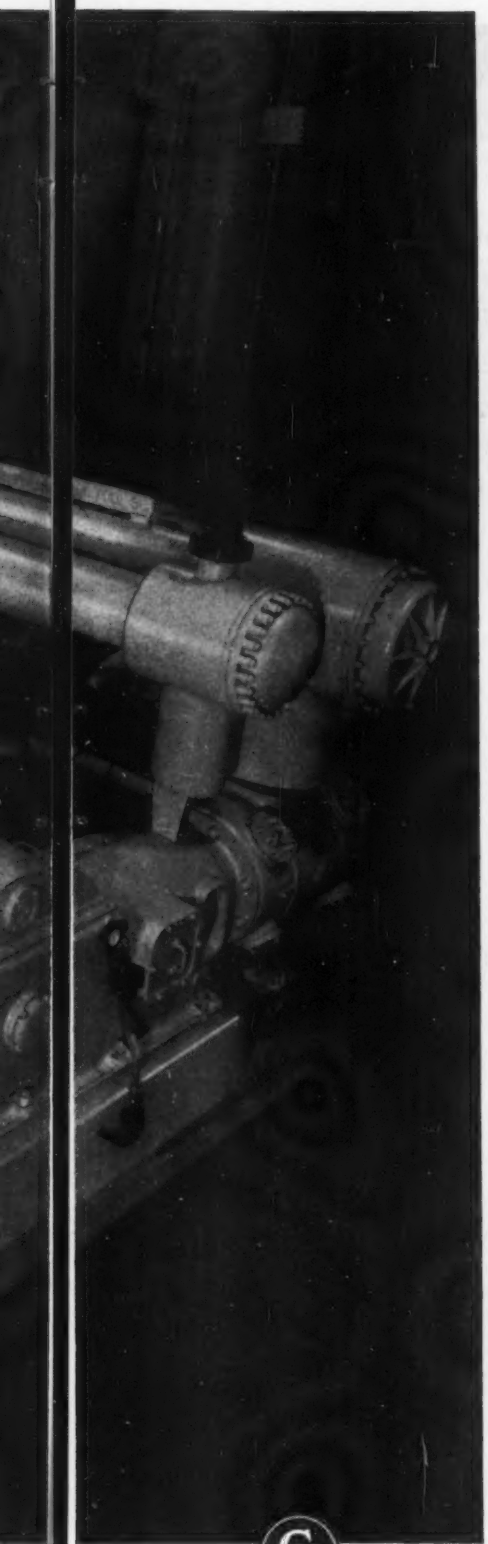
THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y. *Engineering and Sales Offices and Subsidiaries:* New York, Houston, Montreal, London, Paris, The Hague, Bombay. *Sales Offices:* Chicago, Caracas. *Heat Exchanger Plant:* Honesdale, Pa. *Engineering Center:* Newark, N. J.

Lummus engineer points out cracking heaters in model of Petroleum Chemicals, Inc. ethylene plant.

For more data on advertised products, use Readers' Service Cards, last page.



Four-stage Class H Compressors meet air liquefaction demands in a steel plant.

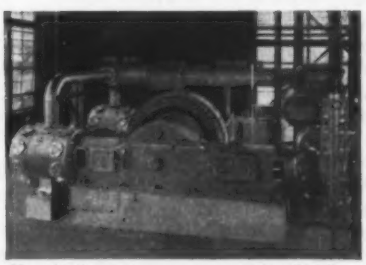


Low Speed

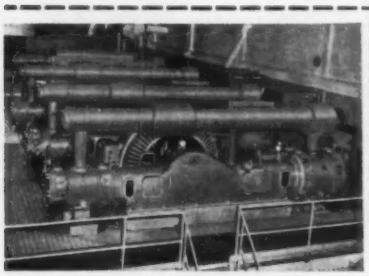
FOUR-CORNER COMPRESSORS

- *maximum availability*
- *minimum attention*
- *greatest accessibility*
- *readily adapted to multi-staging*

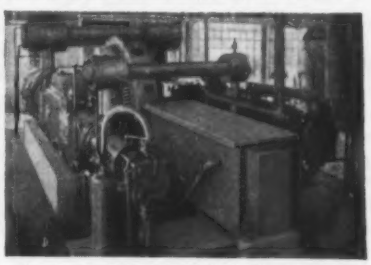
Chicago Pneumatic duplex, four-corner Class H Compressors afford optimum flexibility in arranging cylinders for one to six stages of compression, with correct distribution of load. These Class H Compressors, with motor or steam drive, are built in sizes to 2,000 horsepower for vacuum service or pressures to 15,000 psig. Other types available up to 5,000 horsepower.



Class H, three-stage compressor installed in a chemical plant.



A pair of Class H, two-stage compressors supplies air in a West Coast installation.



Five-stage, four-corner 3,000 psig compressor in Japan — the first of three.

Chicago Pneumatic 8 East 44th Street, New York 17, N. Y.

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS

CORROSION

TYPE	HOW TO IDENTIFY
GALVANIC	Localized deep grooves or pits, often at contact between dissimilar metals.
UNIFORM	Uniform attack—may be on only one part.
INTERGRANULAR	Attack at grain boundaries.
PITTING	Rapid, deep pitting at several small areas. May be uniform or highly localized.

Why you can conquer all four kinds of corrosion with Goulds chemical pumps

When you buy Goulds Fig. 3715 chemical pumps you can build *specific* protection against all four types of corrosion.

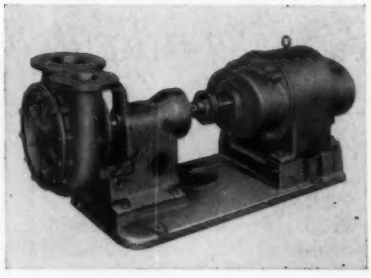
Match the pump metal to your liquids. You can have the *entire* fluid end of the pump made of 316 stainless, Gould-A-Loy 20, nickel aluminum bronze, iron, iron with stainless trim or nickel aluminum bronze trim. These metals from stock. Any machinable alloy on application.

All machined parts in all metals held to same close clearances permitting economical alloy changes in the field . . . the entire liquid end or any component as conditions warrant.

Choosing from this wide range of metals, you can combat the different corrosive actions of hot acids, alkalies, slurries, sizes, or whatever other corrosive liquids you pump.

Match pump size to job

You can get Goulds Fig. 3715 in 9 sizes: capacities to 720 GPM, heads to 200 ft. Other features of Fig. 3715: water-jacketed support head permits handling liquids at 350°F.; impeller clearance can be adjusted without dismantling the pump. For more information, write for Bulletin 725.4.



These larger pumps also fight corrosion

For larger capacities or heads, you can get these other Goulds pumps in metals that resist specific corrosion:

Fig. 3405—single stage, double suction; 19 sizes; capacity to 6400 GPM, head to 425 ft. Bulletin 721.6. Popular sizes available in 316 stainless steel from stock.

Fig. 3305—two stage, opposed impellers; 8 sizes; capacity to 1200 GPM, head to 1000 ft. Bulletin 722.6.

Fig. 3189—single stage, open impeller; 11 sizes; capacity to 1080 GPM, head to 180 ft. Bulletin 720.4.

Goulds PUMPS INC. Seneca Falls New York

Branches: Atlanta • Boston Chicago • Houston New York • Philadelphia Pittsburgh • Tulsa

West Coast Representative: Goulds Pumps Western, Portland, Ore.

In Canada: The A. R. Williams Machinery Co., Ltd. in all principal cities.

Who's Building . . .

acetylene and hydrogen cyanide, both of which are manufactured by Monsanto at Texas City, utilizing natural gas and ammonia supplied by Monsanto's Lion Oil Co. division.

Clark Oil & Refining Corp. has announced plans for a $7.25 million expansion program at its Blue Island, Ill., refinery. Contract for construction of one of the largest fluid catalytic crackers in the Chicago area was awarded to Procon Inc., Des Plaines, Ill.

The giant cat cracker will have a capacity of 12,500-bpd. It is designed by Universal Oil Products Co., Des Plaines. Procon also was awarded the contract to build gas concentration facilities in conjunction with the cat cracker.

Field construction of the new cracking unit began May 1, and completion is scheduled for early 1958. Procon will do the engineering and designing as well as equipment purchasing for the job.

At design throughout the cat cracker will have a coke burning capacity of six tons an hour and circulate 1000 tons of catalyst an hour.

The Fluor Corp., Ltd., Los Angeles, has been awarded a contract to modernize and expand Food Machinery and Chemical Corp.'s carbon tetrachloride plant at South Charleston, W. Va.

This new project is another step in a program of expansion and rehabilitation of the whole South Charleston plant of Food Machinery's Westvaco Chlor-Alkali Division.

At the present time Fluor and Food Machinery and Chemical engineers are completing process and engineering designs. When completed early in 1958, the capacity of this major chemical production facility will be approximately doubled.

Air Reduction Sales Co., a division of Air Reduction Co., Inc., will build a multi-million dollar air liquefaction plant for the production of liquid oxygen, nitrogen and argon at Acton, Mass., near Boston.

The investment in this new plant, to be started late this spring, and in related distribution facilities, will be in excess of $9 million.

The new Air Reduction facility, which is scheduled for completion during the summer of 1958, is designed to produce 75 tons of liquefied gases per day. Current facilities at the Acton site, where Air Reduction already maintains extensive operations, include an acetylene plant, an electrolytic plant for the production of hydrogen and oxygen, and a sub-station for the re-distribution of liquid oxygen and nitrogen produced by Air Reduction Sales at its air liquefaction plant at Riverton, N. J. The new facility at Acton will replace the existing distribution sub-station.

Panama Refining & Petrochemical Co. Inc., Panama City, Republic of Panama, has signed a contract with Foster Wheeler Corp., New York, covering the design, procurement, and construction of a 55,000 bpd refinery at Colon. Work on the 33 million dollar project will begin in another 60 to 90 days and will have a completion date of less than two years.

Panama Refining & Petrochemical Co.

For more data on advertised products, use Readers' Service Cards, last page.

ONE-FOOT SAMPLE OF ALCOA ALUMINUM ELECTRICAL RIGID CONDUIT!

Alcoa wants to send you a free sample of standard *Underwriters' approved* aluminum electrical rigid conduit. We want you to examine it closely. Compare it with other conduit. Bend it. Thread it. Feel the factory-applied internal lubrication that makes wire pulling easy. Hit it, see how it stands up. Test it any way you wish. See for yourself how much better it stacks up than any other conduit you've used. Consider these advantages:

- *Corrosion resistance.* Resists attack. Far outlasts ordinary conduit. Needs no painting. Requires less maintenance. Ends costly replacement.
- *Good appearance.* Ideal for food processing, dairy, refinery, brewery and similar applications. It won't stain. Stays good looking.
- *Light weight.* Save on installation. Use lighter supports. Easier to store, handle, install. Weighs only a third as much as steel. Installed cost is only slightly more than steel in smaller sizes; bigger sizes, actually less.
- *Nonsparking.* Safer for hazardous locations.
- *Nonmagnetic.* Less voltage drop means smaller wire sizes can be used . . . or longer runs. Conductors can be separated regardless of load.
- *Stocked.* Conduit warehoused by Alcoa distributors throughout the country. Fitting manufacturers make a full aluminum line—also available are thread cuttings and joint compounds from Alcoa.

To get your sample of Alcoa® Conduit—and full information, just fill in the coupon below.

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Alternate Sunday Evenings

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2325-F Alcoa Building, Pittsburgh 19, Pa.

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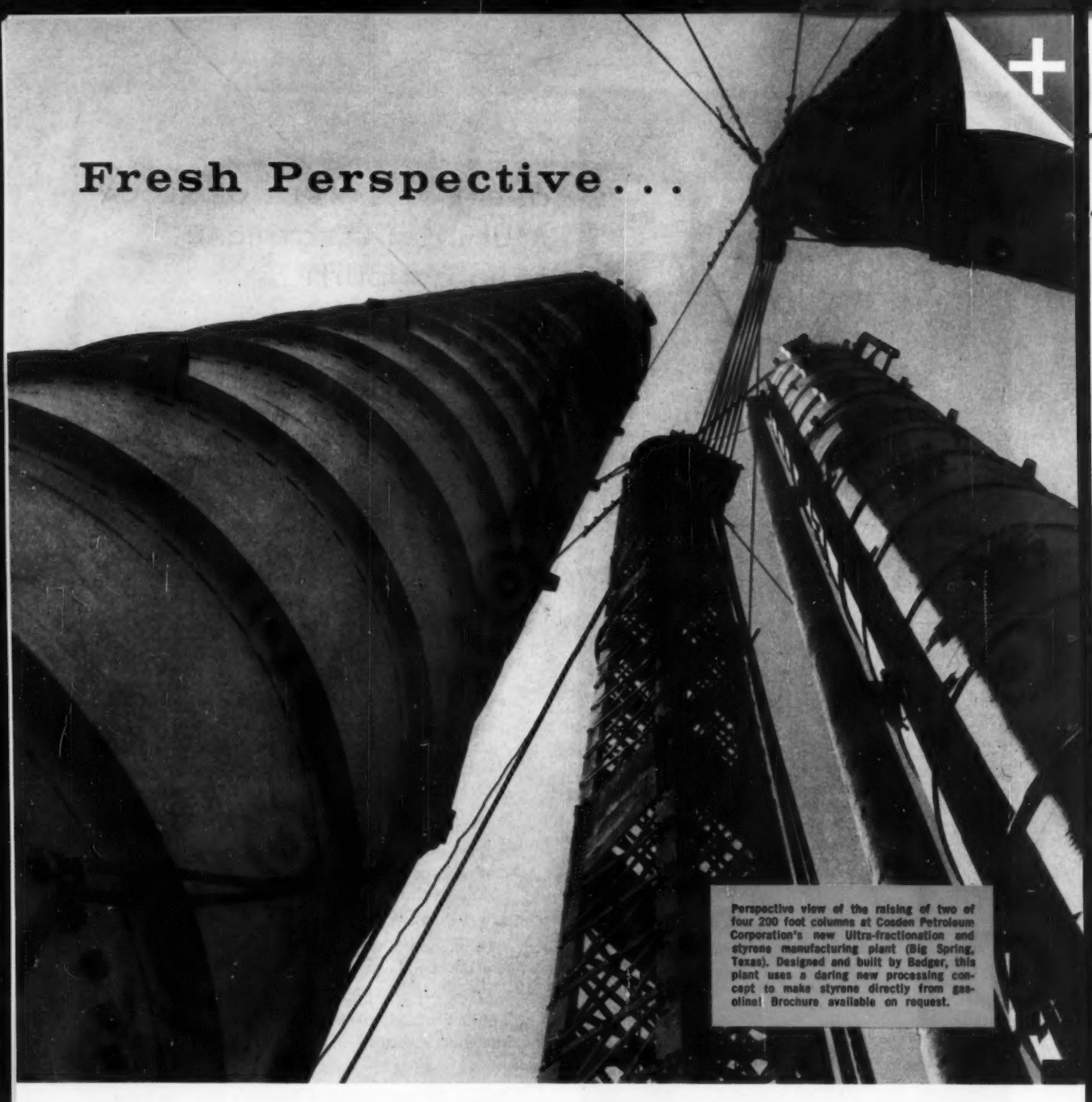
Fresh Perspective . . .



Perspective view of the raising of two of four 200 foot columns at Cosden Petroleum Corporation's new Ultra-fractionation and styrene manufacturing plant (Big Spring, Texas). Designed and built by Badger, this plant uses a daring new processing concept to make styrene directly from gasoline! Brochure available on request.

+ The ability to put engineering problems in a *fresh perspective* — to subject them to a point of view that leads to new solutions — is at the root of Badger accomplishments like these:

. . . a commercially practical method of separating ethylbenzene from gasoline by Ultra-fractionation.

. . . a continuous process for producing sodium-hydrogen compounds.

. . . the successful application of a new process for deriving high quality light oils from coal — without acid treating.

An intangible that has been called "The Precious Plus behind a Badger blueprint," this refreshing ability to apply *new* thinking to difficult engineering problems has produced two important results:

1. Top petroleum and chemical processors are securing better processes, more economical plants.

2. Badger has become one of the world's fastest growing contract engineering firms.

Whether your project is commonplace or complex, calling in Badger is the first step toward securing the precious advantages that can come only from taking a *fresh perspective.*

Badger's Key Man Operating Policy: "The Badger man who submits your proposal is always a Badger principal — always the Key Man responsible for the execution of your job."

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ENGINEERS • CONTRACTORS • DESIGNERS • MANUFACTURERS

Who's Building. . .

Inc., owners and operators of the new refinery, is owned jointly by the partnership of Eugene duPont, III, of Wilmington, and John Shaheen of New York. Shaheen stated in New York, "We have signed contracts with several major U. S. oil companies for a 10-year supply of crude and have also signed contracts for the entire output of the refinery for the next 10 years."

Foster Wheeler Corp., New York engineering firm, is prime contractor for the new installation, which will be the first in the Republic of Panama.

Navy Department has unveiled plans for a $17 million shale oil refinery at Rifle, Colo., with an estimated capacity of 50,000-bpd. Though Chairman of the House Armed Services Committee Carl Vinson (D-Ga.) has placed his seal of approval on the project, it is not likely that the proposal will be able to elude a lot of opposition from members of Congress.

Generally, it looks as if the majority of the opposition will fall into the following different classifications:

1. Those who oppose the government entering any type of business.

2. Those who think that the Bureau of Mines is better qualified and more experienced to carry out a shale oil program.

3. Those who think that either the Navy or the Interior Department should have jurisdiction over the program, but who also think the door should be left open to private enterprise to either buy or lease at a later date.

The Girdler Co., Louisville, Ky., has been authorized to design a gas purification plant to be installed at the Baytown, Texas refinery of Humble Oil & Refining Co., and to supply equipment for it.

The plant will consist of three complete purification trains. They will provide a maximum flexibility and on-stream factor. The refinery gas streams, totaling 2.77 million cubic feet per hour, are to be treated with a solution of diethanolamine and water.

The project was subcontracted to Girdler by the M. W. Kellogg Co. Kellogg will erect the unit in connection with other work the company is carrying on at the refinery.

Thailand Government has reached a tentative agreement with a Japanese firm to build a 15,000 bpd refinery near Bangkok. The plant, which would be Thailand's first, would be built by Nippon Steel Tube Co. with special Yen funds or military currency issued in Thailand during World War II.

The Japanese firm will extend a $1.1 million loan to meet the total $28 million estimated cost.

Norddeutsche Affinerie, Hamburg, Germany, has concluded a license agreement with L. Sonneborn Sons, Inc., for the erection of a Miley Acid Sludge Decomposition Retort at Norddeutsche's metal refinery in Hamburg.

This is the third such license agreement made by Sonneborn, the others being with Stauffer Chemical Co. for its plant at Hammond, Ind. and Gulf Oil Corp. for its refinery at Port Arthur, Texas. Sonneborn also operates three of the Miley units

EXCLUSIVE WITH TIDEWATER DELAWARE CITY REFINERY—
141 DUCON CYCLONES INSTALLED FOR CATALYST RECOVERY

High Efficiency Attested by Leading Oil Refineries...

DUCON CATALYST RECOVERY CYCLONES

Recovery of valuable catalyst in regenerator and reactor systems makes a big difference in the efficiency and costs of oil refining. Ducon Type SDC Cyclones, with the exclusive helical inlet feature, have proved themselves the world over for their dependable high operating effectiveness, and maximum catalyst recovery for constant reuse.

TYPICAL APPLICATIONS
for Ducon Cyclones and Trickle Valves
FLUID CATALYTIC CRACKING • FLUID COKING
FLUID HYDROFORMING • ELUTRIATOR TOWERS
THERMOFOR CATALYTIC CRACKING
ALL FLUID SOLIDS PROCESSES

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THE Ducon COMPANY INC.
147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK
CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

Who's Building...

at its refinery in Petrolia, Pa.

Inventor of the Miley Process is G. Hunter Miley, manager of the acid-recovery plant of the Daugherty division of Sonneborn in Petrolia. Under the new process developed by Miley, waste acid sludge formed by white oil manufacturing processes is profitably converted into two valuable by-products: sulfuric acid and activated coke (Full process description PETROLEUM REFINER, Sept. 1955, p. 138).

Irving Oil Ltd., is considering building a refinery in the Maritime Provinces. Both Halifax, Nova Scotia, and St. John, New Brunswick are being considered as possible site for the refinery.

Allied Chemical & Dye Corp. General Chemical division, has authorized The Girdler Co. to design and build a sulfur recovery plant at Linden, N. J.

General Chemical will use hydrogen sulfide from the Bayway, N. J., refinery of Esso Standard Oil Co. to produce approximately 60 tons per day of elemental sulfur.

The Girdler sulfur recovery plant will be designed for maximum sulfur recovery, thereby minimizing escape of material to the atmosphere at all levels of production. A mass spectrometer will be employed to analyze plant tail gases. Any residual compounds will be incinerated prior to discharge into the atmosphere.

Engineering work on the new plant was started by Girdler in January. The project is scheduled for completion late in 1957.

STERLING INTERESTS?

Holtspur Engineering Co., Limited are interested in Manufacturing Equipment for the Oil Refining/Processing Industry under license from a Reputable, Established Progressive Concern.

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TEL: HIGH WYCOMBE 2187.

Southland Oil Co.'s expansion of its Memphis refinery has been hampered and slowed down considerably because of slow delivery of materials and continued rains.

Completion of the first phase of the construction which will increase the crude capacity from 6000 to 12,000 bpd has been postponed by six months, and is now slated for June. The second phase which will further increase capacity to 22,000 bpd was originally scheduled for October, but now it looks as if this phase will also be delayed.

Plans for a Florida refinery by the company's affiliate Southland Oil Co. (Florida) have also been delayed. The plant which is to be located near Black Point, Fla., has been delayed primarily by high tanker rates and a shortage of steel.

Scientific Design Co. has designed and placed on stream, the first American package plant for producing polyvinyl chloride resins. The plant which was erected by SD Plants, Inc., was built for Eleonora Chemical Corp., a subsidiary of Pantasote, Inc., on a site adjacent to the Pantasote plant. The new plant will produce 10 million pounds per year of PVC to be used in the production of vinyl film and sheeting.

Cost of the new plant was reported to be under $1 million including design and engineering. Actual construction was completed in six months. The plant was designed for flexibility of operation, to permit the production of resins tailor-made to meet requirements. With small modifications, the plant can produce other resins, such as polystyrene and vinyl co-polymers.

Shell Oil Co. has started up a 16,000-bpd Platformer at its Wood River, Ill., refinery. This gives Shell the largest concentration of operating Platforming units at any refinery. It now has a total Platforming capacity of 36,000-bpd.

The latest unit is an exact duplicate of the one which went on stream in August, 1954. All three Platformers are producing high octane blending components for use in Shell's regular and premium gasolines.

Standard Oil Co. of California, Western Operations, Inc., will construct multi-million dollar catalytic reformer plants at its Richmond and Bakersfield refineries. Designed to increase output of the higher octane gasolines Standard is now marketing, the two plants are expected to be ready for operation by mid-1958.

The Richmond project will be patterned after twin catalytic reformers the company built at its Richmond and El Segundo refineries two years ago. The Bakersfield plant will be somewhat smaller.

Both developments are part of Standard's over-all plan to increase the quality of its premium and regular grade gasolines.

Tennessee Gas Transmission Co. will build a natural gas processing plant to serve the West Edison area of Lea County, N. M. The plant will be located about 15 miles southwest of Lovington, N. M., in the Kemnitz block, where Tennessee Gas now has oil and gas production.

Designed as an absorption-type plant, it will have an initial capacity of 10 million cubic feet of natural gas per day, and will have a daily production of approximately 43,000 gallons of propane, butanes and

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You get the best combination of safety (action on air failure) with maximum potential thrust, plus inherent simplicity and reliability in Masoneilan Spring-diaphragm Motors for single seated control valves.

Many single seated valves are specified to close on air failure. Hence the initial spring compression must provide the force for closing, since the valve would normally be installed with flow tending to open. Thus, to overcome unusual off-balance forces, a high *initial* thrust must be developed.

On air-to-close valves, the motor should develop a high net thrust at the *end* of the stroke. Thus, to overcome unusual off-balance forces a high *final* thrust is essential.

The design of Masoneilan motors enables you to obtain high *initial* thrust or high *final* thrust or, in the case of three-way valves, *both* high initial and final thrust, using, in most cases, standard springs.

Here's how —

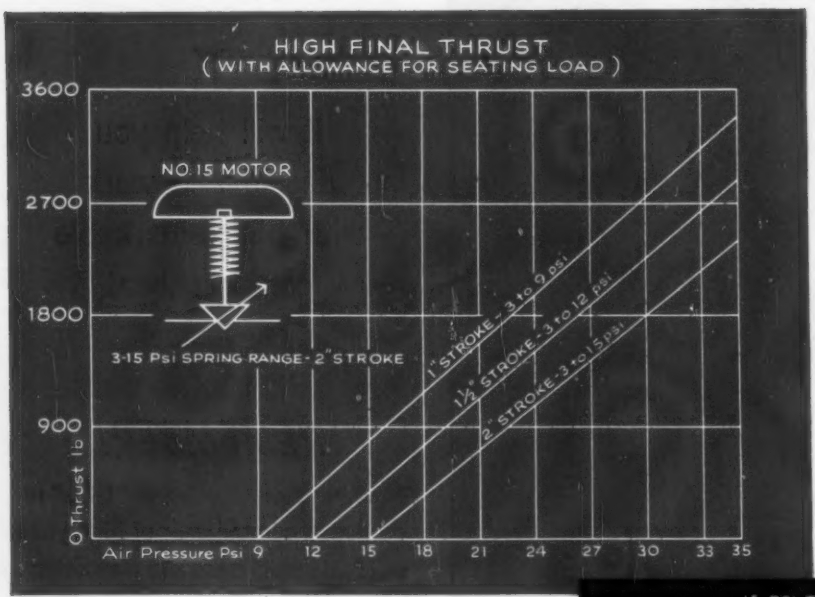
HIGH INITIAL THRUST: Usually an oversize motor is used with a standard spring, but with the difference in stroke used to gain more initial compression and consequent additional spring force.

HIGH FINAL THRUST: The normal size motor often is used by simply increasing the air supply pressure to 30 or 35 psi. If necessary an oversize motor can be used to obtain even greater final net thrust.

HIGH INITIAL AND FINAL THRUST: Using an oversize motor permits adjusting the spring setting to obtain high initial thrust and makes an excess of supply pressure available for high final thrust.

Example — No. 18 Motor with 3½" Rated Stroke and 6-30 psi Spring used on Valve with 2" Stroke.

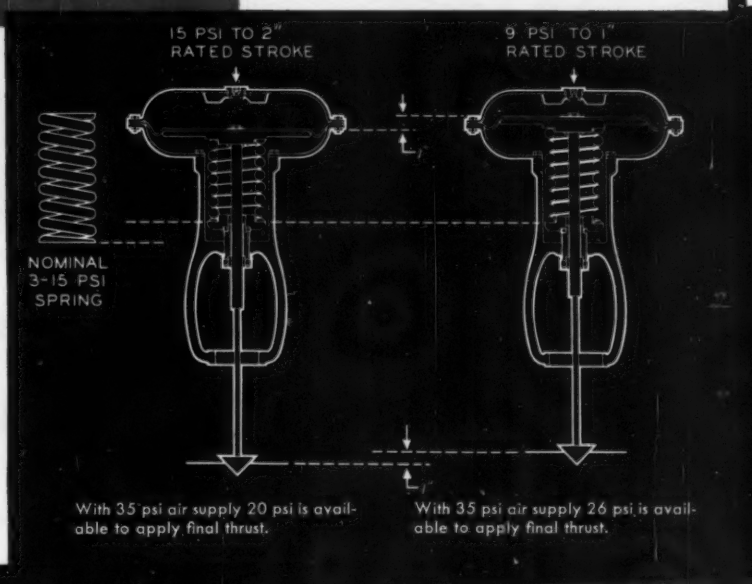
The spring can be set for 8-22 psi nominal range, giving an initial diaphragm load of 8 psi and (with 30 psi supply) 8 psi is also available for final thrust.


HIGH FINAL THRUST
(WITH ALLOWANCE FOR SEATING LOAD)
3600
2700
1800
900
0 Thrust lb
NO. 15 MOTOR
3-15 Psi SPRING RANGE - 2" STROKE
1" STROKE - 3 to 9 psi
1½" STROKE - 3 to 12 psi
2" STROKE - 3 to 15 psi
Air Pressure Psi 9 12 15 18 21 24 27 30 33 35

Tabulated data are available for facilitating correct control valve selection. Ask our nearest office for Data Sheet 10-11 — or write Mason-Neilan, Division of Worthington Corp., 51 Nahatan St., Norwood, Massachusetts.

HIGH FINAL THRUST:

Example — No. 15 Motor with 2" Rated Stroke and 3-15 psi Spring used on Valves with 2" and 1" Strokes.


15 PSI TO 2"
RATED STROKE
9 PSI TO 1"
RATED STROKE
NOMINAL
3-15 PSI
SPRING
With 35 psi air supply 20 psi is available to apply final thrust.
With 35 psi air supply 26 psi is available to apply final thrust.

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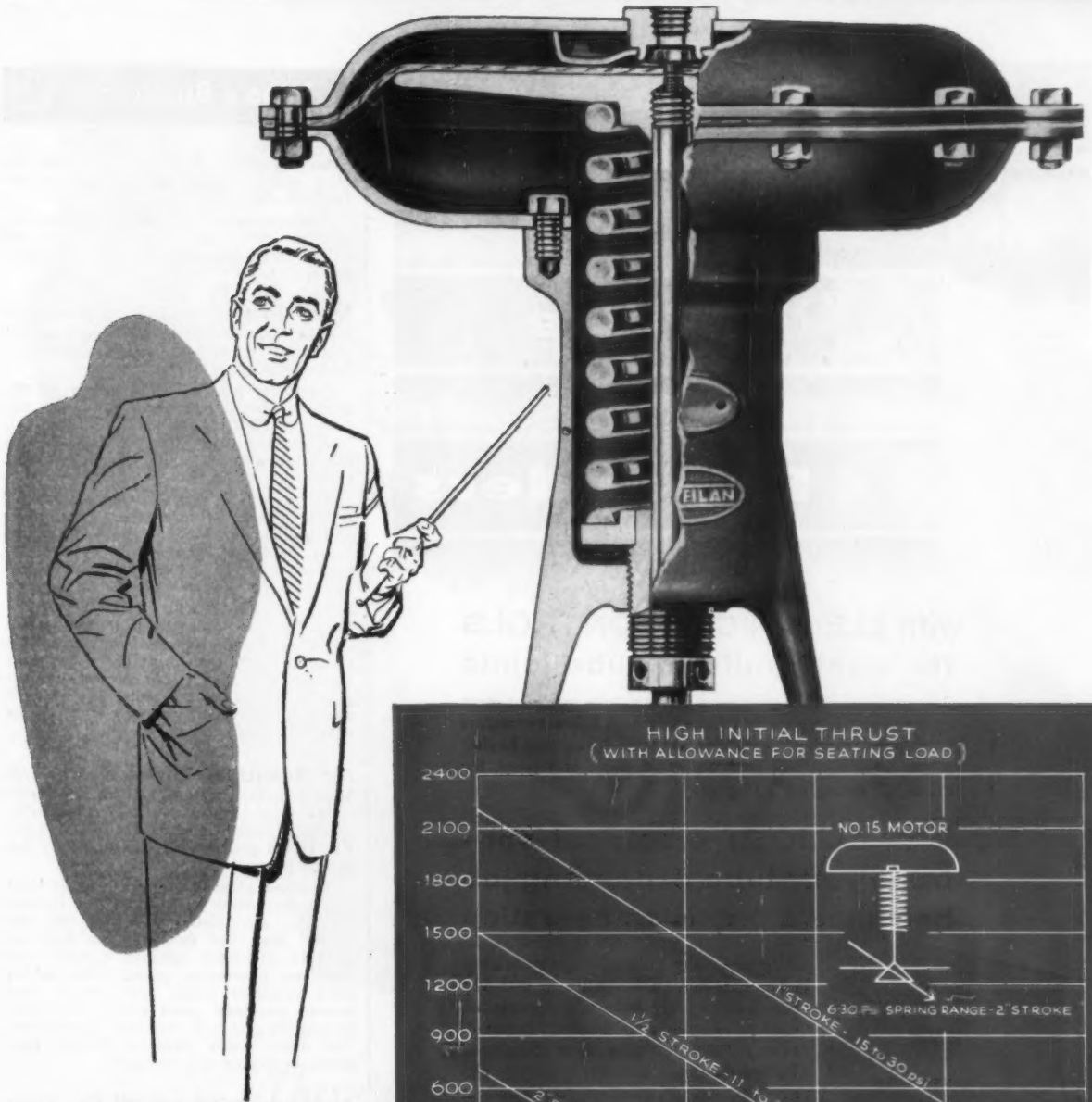
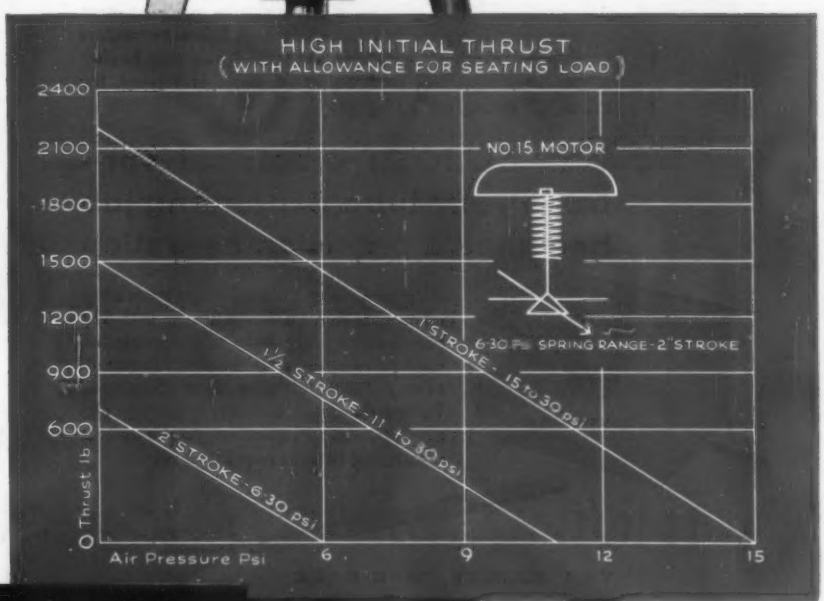
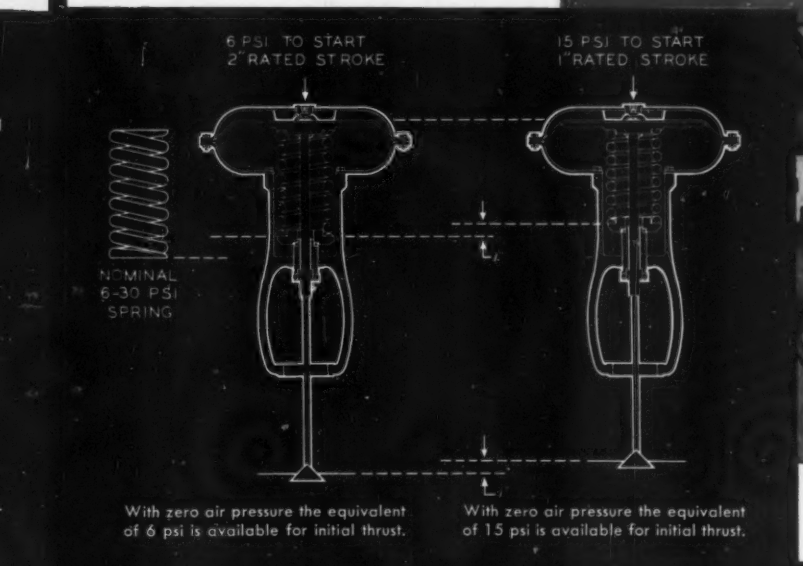




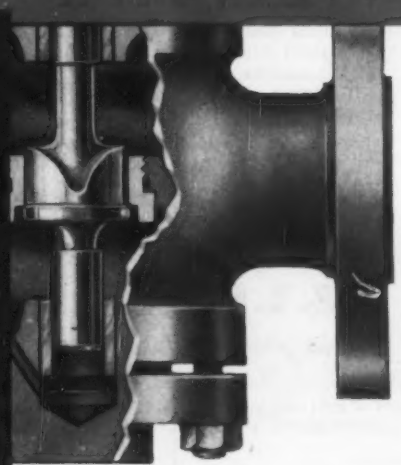
HIGH INITIAL THRUST:

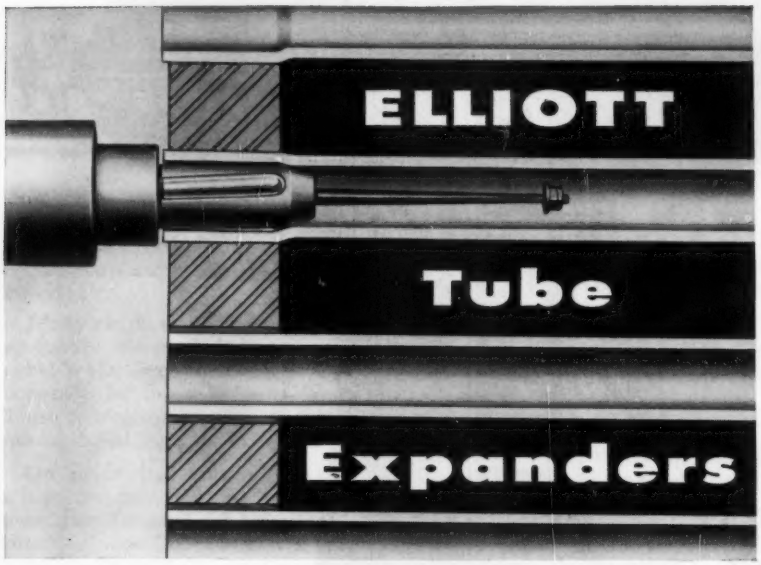
Example — No. 15 Motor with 2" Rated Stroke and 6-30 psi Spring used on Valves with 2" and 1" Strokes.



With zero air pressure the equivalent of 6 psi is available for initial thrust.

With zero air pressure the equivalent of 15 psi is available for initial thrust.





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Assures air- or water-tight joint between tube and tube sheet by use of rotating, parallel self-feeding rolls. Elliott expanders have adjustable ball-bearing thrust collars, and rolls having a radius on front and back ends. Available in 4 types, for tubes ¼″ through 3″, 14 gage.

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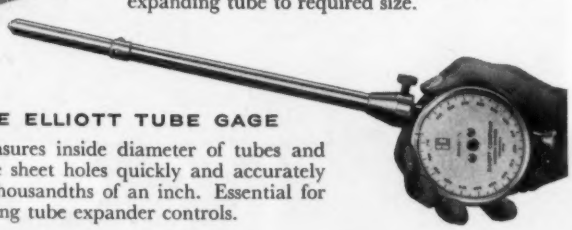

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Who's Building...

natural gasoline. It is expected that the plant will be placed in operation in late 1957 or early 1958.

Tennessee Gas now operates three natural gas processing plants in Texas and a hydrocarbons extraction plant in Kentucky.

Shell Oil Co. will build a new multimillion dollar Platforming unit to expand production of high octane gasoline at its Norco refinery in Louisiana.

Contracts for the construction of the auxiliary facilities have been let to the Foster-Wheeler Co., and the Pritchard Co. The contractor for the Platformer unit construction will be announced in the near future.

The new refinery unit will increase the octane number of more than a half million gallons per day of gasoline components used for blending into premium gasoline fuel. It is expected to be completed by the summer of 1958.

The Platformer will consist of two sections. The first, a desulfurizer, removes the sulfur present in gasoline stocks manufactured in other units at the refinery. In the second section of the process, the octane number of the desulfurized gasoline stocks is increased by means of a process using the platinum catalyst.

Air Reduction Chemical Co. will build a methyl butynol, and tertiary acetylenic alcohol plant with an annual capacity of three million pounds at Calvert City, Ky. Initial production is expected by fall of this year.

The new plant is the fourth to be built by Air Reduction on its 1500-acre Calvert City site, assembled for its own and customers' use. The first was the National Carbide division's calcium carbide and acetylene generating plant, from which three customer plants and Airco's vinyl acetate monomer plant receive acetylene by pipeline, as will the new installation. The other Airco plant at Calvert City produces oxygen and nitrogen.

Anderson-Prichard Oil Co., Oklahoma City, will increase its refining capacity by 7500 bpd in June when it completes its two-prong building program. The company is adding a reactor regenerator section to its catalytic cracking unit and is rebuilding its gas-recovery system at Cyril, Okla. This will boost capacity from 10,000 to 12,500 bpd. A new crude distillation unit is being built at the Arkansas City, Kan., plant. This will increase capacity from 20,000 to 25,000 bpd.

Indian and French industrialists, the National Iranian Oil Co. and the Greek shipping magnate, Aristotle Onassis, are reported to have completed their joint proposals for the building of an oil refinery in the Island of Ceylon.

The three-way combination will see Indian and French interests financing the project, the National Iranian Oil Co. supplying crude oil, and Onassis looking after tanker transportation.

Negotiating on behalf of this group with the Government of Ceylon, Indian multimillionaire H. C. Dinshaw has asked for two concessions: monopoly rights to refine and distribute petroleum products in Cey-

For more data on advertised products, use Readers' Service Cards, last page.

The Rockwood Dualsteel Union was made especially to handle highly corrosive material

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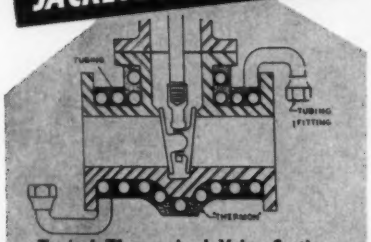

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8. RAPID DELIVERY—use of standard equipment permits minimum delivery time.

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Who's Building. . .

lon, and reduced import duties. Significance of these concessions need no elaboration and Ceylon now depends completely on imported petroleum products.

The combine is optimistic it could supply a million gallons of crude oil annually in Ceylon at a price which will be 20 percent less than the present market price.

Three other offers in connection with the same project were received earlier by the Government of Ceylon and they are all said to be still under consideration. These are from an Anglo-American group represented by Shell, British Petroleum and Caltex; from an independent American Oil Co; and from a group of Russian oil interests.

Ceylon was a Crown Colony of the British till 1947, when she became free along with India and Burma. She is still within the British Commonwealth.

Berry Refining Co. has placed in operation a combination UOP Platforming and Unifining unit at its Gary, Ind., refinery.

The Unifining unit is serving as a pretreating facility for the Platformer, processing a full boiling range gasoline derived from high sulfur content Wyoming crude. The Platforming unit has a design capacity of 1650 bpd at a scheduled leaded octane rating of 98.

Company officials said the new combination unit will enable the refinery to produce 100 percent of its gasoline as high quality premium grade motor fuel whenever required.

Universal Oil Products Co., Des Plaines, Ill., designed, engineered and licensed the combination unit.

Continental Oil Co. will further modernize its Wichita Falls refinery, at an estimated cost of $1.5 million. Construction work on a 3500-bpd catalytic reforming unit is expected to start this summer, with completion estimated by early 1958. The plant now has a daily capacity of 9500 barrels.

Greek Government's new 30,000-bpd refinery at Aspropygros 12 miles west of Athens, is expected to go on stream in mid-July. The plant is being built for the government by Hydrocarbon Mineraloel, G.m.b.H., Dusseldorf. A 14-mile 12-inch pipeline will connect the plant to storage facilities already built at Megara on the Bay of Eleusis.

British American Oil Co., Ltd., has announced plans for the construction of a new multi-million dollar refinery at Port Moody, B. C., near Vancouver. The refinery, which will have a daily capacity of 20,000 barrels, will serve the Vancouver and West Coast markets.

Scheduled for completion in late 1958, the refinery will be located on a 400-acre site adjacent to B-A's Burnaby marketing depot. It will be completely integrated. In addition to topping and vacuum facilities, the main installations will include catalytic cracking catalytic reforming and alkylation units for the production of high octane gasolines.

Contract for building the refinery has been awarded to Canadian Kellogg Co., Ltd., and preliminary construction is getting underway.

Cia. Petrolera Shell de Cuba has placed on stream a UOP Platforming unit, the first built in Latin America. The unit has a design capacity of 5500 bpd, and is processing naphthas, boiling in the range of 185 F. to 365 F., derived from the Venezuelan Lagomar and Oficina crudes.

The unit is designed to produce a 97 leaded octane blending component. Universal Oil Products Co., Des Plaines, Ill., did the design and engineering work, and also licensed the unit.

The Standard Oil Co. (Ohio) has awarded a $2,400,000 prime construction contract for a new alkylation unit at its Cleveland No. 1 refinery to Arthur G. McKee & Co., Cleveland.

This new unit, similar to the alkylation unit which was built at the Sohio refinery at Toledo in 1953, will utilize a process designed by M. W. Kellogg Co. and is the same process used in producing high octane aviation gasolines. The feed stock will be butane gases which will be converted with sulphuric acid catalyst to 100-plus high-octane gasoline blending stock.

The maximum feed rate to the new alkylation unit will be 230,000 gallons per day with a product maximum of 150,000 gallons per day of 100-plus octane gasoline components.

Construction was expected to start June 1, 1957, on this new unit which is expected to reach a total cost of about $3.4 million including auxiliaries. The unit is to be completed May 1, 1958.

The Fluor Corp. has announced that foundations are now being poured for the latest addition to The Texas Co. gigantic Port Arthur, Texas refinery. The Fluor, which also handled the mechanical engineering on the new crude unit, started field construction work in February.

The next major step scheduled is the installation of equipment. This will include installing five vertical heaters and a 165 ft.-high crude tower, one of the largest ever to be built.

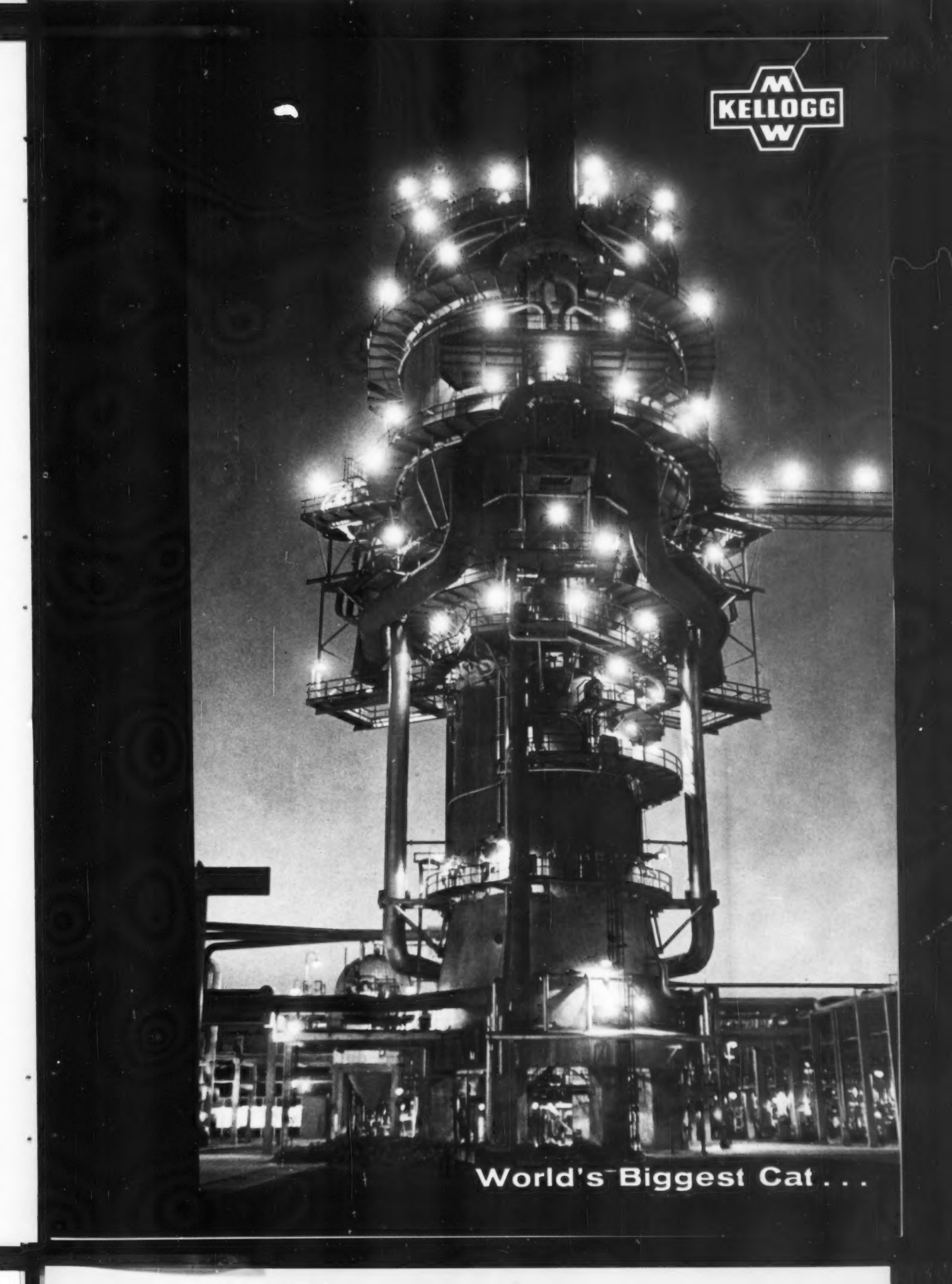
The 80,000 bpd vacuum pipe still will be one of the largest crude units in operation. When this goes on stream, Texaco will withdraw from operation existing units having a daily charge capacity of 60,000 bpd, resulting in a net increase of 20,000 barrels per calendar day.

The new unit will process a variety of crudes to produce propane and lighter hydrocarbons to the refinery fuel gas system. It will also produce liquid butane, light and heavy straight-run gasoline, two atmospheric gas oil cuts, three vacuum gas oil cuts, a decarbonized residuum and cut back asphalt.

Major sections in the new pipe still include a desalting unit, crude and vacuum fractionation unit, light ends fractionation unit, H2S removal unit and a decarbonization unit for the production of high-grade catalytic cracking charging stock from vacuum residuum.

The project is scheduled for completion early next year.

Instituto Venezolano de Petroqiomoca is in the process of erecting a completely integrated refinery near Puerto Cabello. The 2500-barrel capacity plant was sold by the Tefco-Inter-America Corp., Houston. The refinery is built entirely on skids to facilitate shipping and assembly. Already several large pieces of equipment have moved through the Port of Houston,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FLUID CATALYTIC CRACKER

developed and engineered

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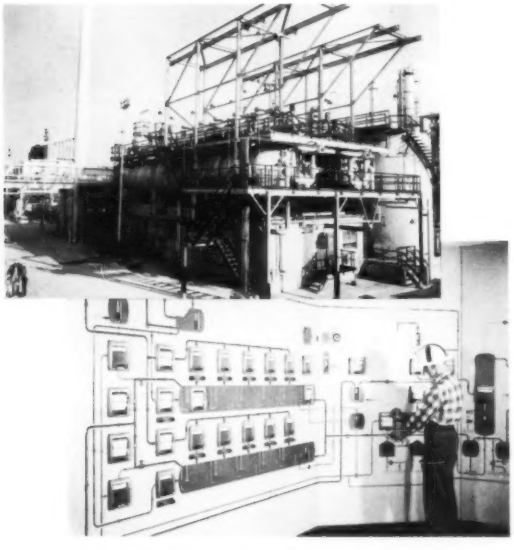
A throughput capacity of 102,000 BPD makes the Orthoflow Fluid Catalytic Cracking Unit, shown here and on the preceding page, the largest in the world. Engineered by The M. W. Kellogg Company for Tidewater Oil Company's Delaware Refinery, south of Wilmington, this Orthoflow is the culmination of Kellogg's experience in engineering 66 fluid catalytic cracking units throughout the world, of which 16 are Orthoflow units.

Kellogg welcomes the opportunity of demonstrating to other refiners, as it did for Tidewater, the numerous advantages of the Orthoflow design.



Kellogg Also Developed and Engineered Tidewater's Sulphuric Acid Alkylation Unit

With a design capacity of 5,000 BPD of alkylate, and a potential capacity of 9,000 BPD, Tidewater's alkylation unit at the Delaware Refinery is one of the largest in operation. Interior view shows controls for the two 5-stage reactors.

Refinery Process Division

The M. W. Kellogg Company

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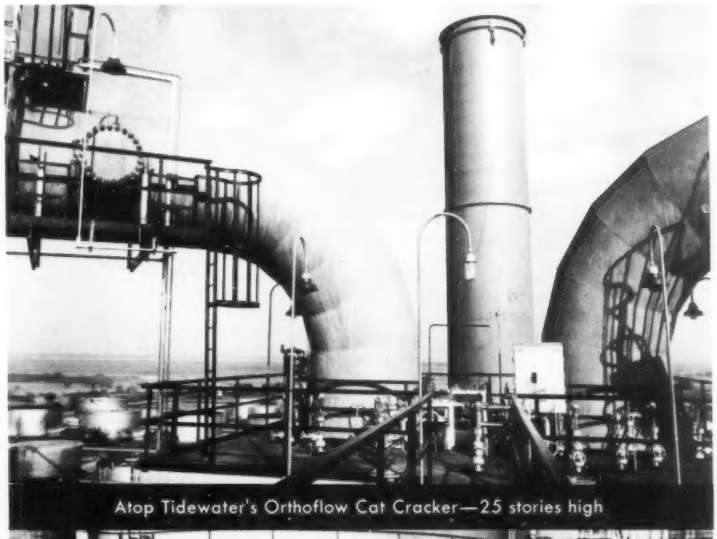
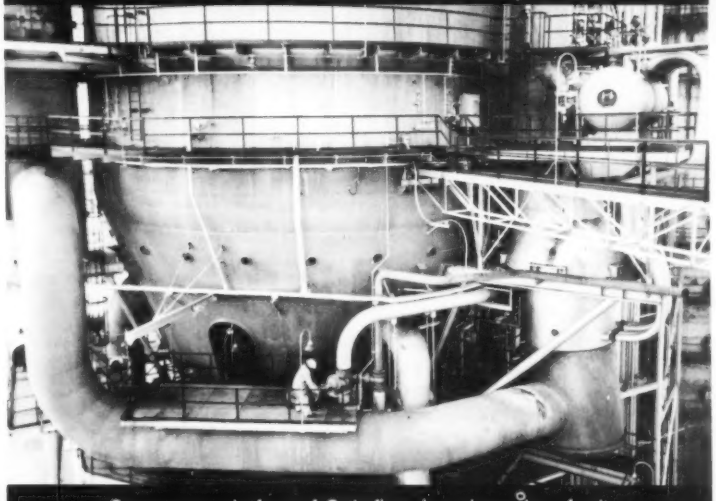
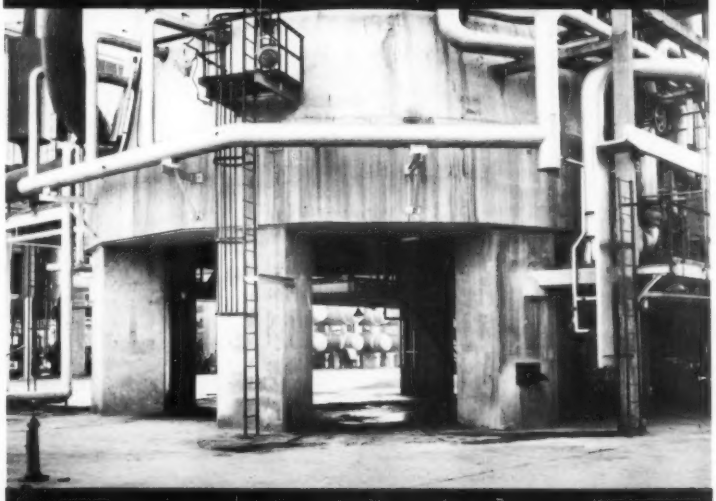


Atop Tidewater's Orthoflow Cat Cracker—25 stories high



Operator on platform of Orthoflow shows huge size of unit



Base of Orthoflow typifies its compact, functional design

Who's Building. . .

and other skid mounted sections are being crated for shipment.

The refinery, which is of the most modern design, has been completely engineered and pre-fabricated in the Houston area under the supervision of Tifco officials.

Tifco president, D. R. Neighbors, said parts of the refinery will be shipped to Venezuela through the spring months. A contractor in Venezuela will assemble the refinery under American supervision, and it should be ready to put into operation this fall.

A novel plan was devised to make reassembly of the refinery more positive, said Neighbors. Each unit in the process was painted a different color, and all connections were painted in two colors to show which two units they connect.

Engineers say that the complex refinery has been reduced to its most simple form, and that inexperienced personnel could assemble it with a minimum of trained supervision.

The refinery was designed for Trifco by Pona Engineers, Inc.

Delhi-Taylor Oil Corp.'s new chemical division, announced that the division's new petrochemicals plant will go on stream July 1. Located in Corpus Christi, Texas, the $4 million plant has ample facilities for water shipment. The Udex extraction unit has a capacity of 45 million gallons per year. Initial production will include benzine, toluene, and xylene. Studies are presently well under way for the production of additional petrochemicals.

Ethyl Corp. plans to build a distribution terminal for "Ethyl" antiknock compound at Everett, Wash. This latest addition to Ethyl's distribution network will be located to serve the entire Puget Sound area in which a number of major refiners are locating or expanding.

The new terminal, to be completed in the summer of 1957, will be located on property leased from the Port of Everett.

American Oil Co. has officially dedicated its asphalt terminal at Panama City, Fla.

Located on a 16-acre site on Watson Bayou, the plant has seven tanks with a total storage capacity of 6.51 million gallons of asphalt. The main feature of the terminal is equipment that permits the unloading of hot asphalt at 325 degrees keeping it at the temperature or hotter and delivering the asphalt in that same state. The hot asphalt comes in by ship and can be delivered to tank trucks, railroad tank cars or barges.

The principal advantages of hot asphalt are that it can be delivered faster and more efficiently at the terminal, and at the same time enable contractors and highway departments to speed their jobs to completion. This new plant will serve an area within a radius of about 150 miles of Panama City.

Although the plant has been in limited operation since late last fall, installation within the next few weeks of a booster heating system and three additional 35,000 gallon tanks will complete the facilities.

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Another adaptation is designed specifically for motor start-up and shutdown. It has also been successfully adapted for supervisory control, pump control and programming.

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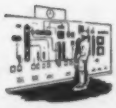
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Why Centralized Training?

This popular training method prevents duplication of effort and concentrates training activities in the hands of qualified personnel.

Carl Mullins White
Service Pipe Line Company
Tulsa

HOW CAN employe training best help meet today's critical shortages in efficient workers, leaders and scientists?

Many of the larger oil companies are concentrating their training efforts in a strong central section of highly qualified professionals.

More than half of the larger oil companies (employing more than 500) now have central training sections. About three out of every five who do not have such sections, express a desire to create them.

Over the past two and a half years, in cooperation with the University of Tulsa and representatives of the petroleum industry, we surveyed the training practices of large American oil companies.

The first phase of this research was a general investigation of training trends. Fifty of the largest oil companies—employing 452,611 people—were questioned. Each answered 535 questions, giving a total of 26,750 statistical items about their methods, subjects, equipment, instructors, and means of coordinating training.

Twenty-five companies reported having central training sections. Two others created theirs shortly after the report was compiled. The keen inter-

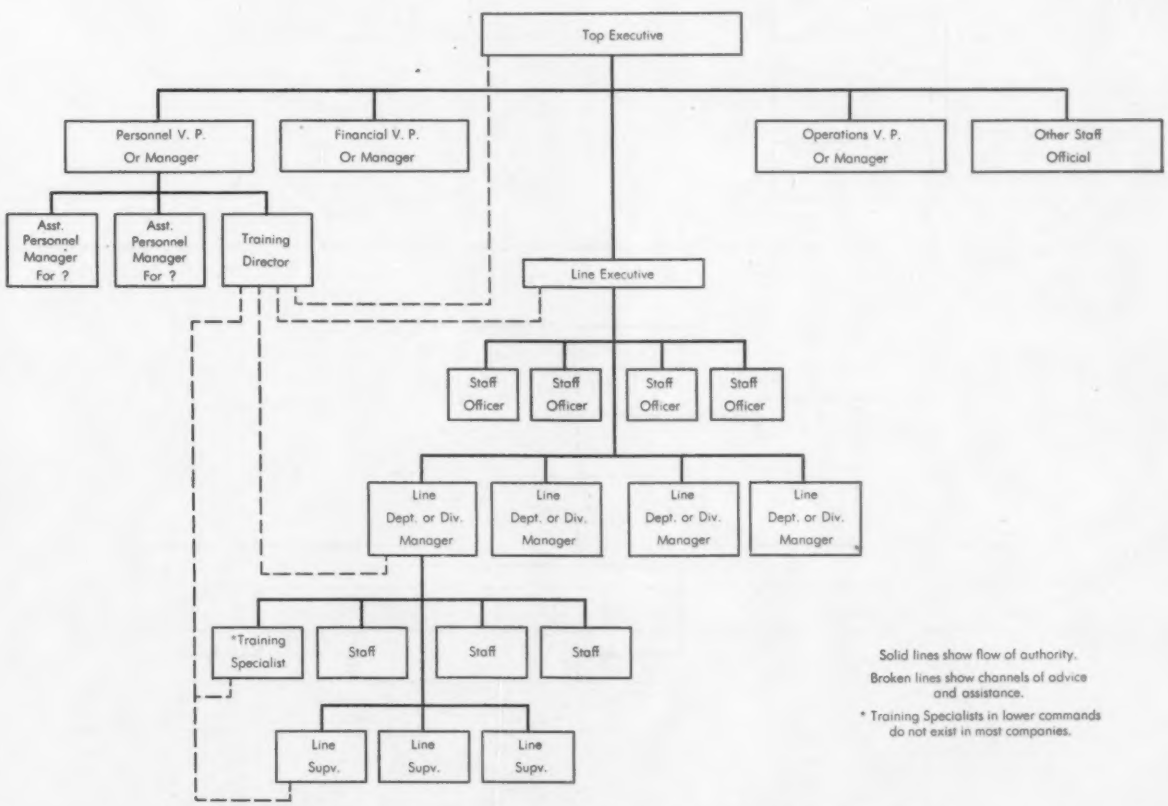


FIGURE 1—Suggested line and staff organization, showing where training personnel might fit in.

est in centralized training uncovered by the first survey led to the second.

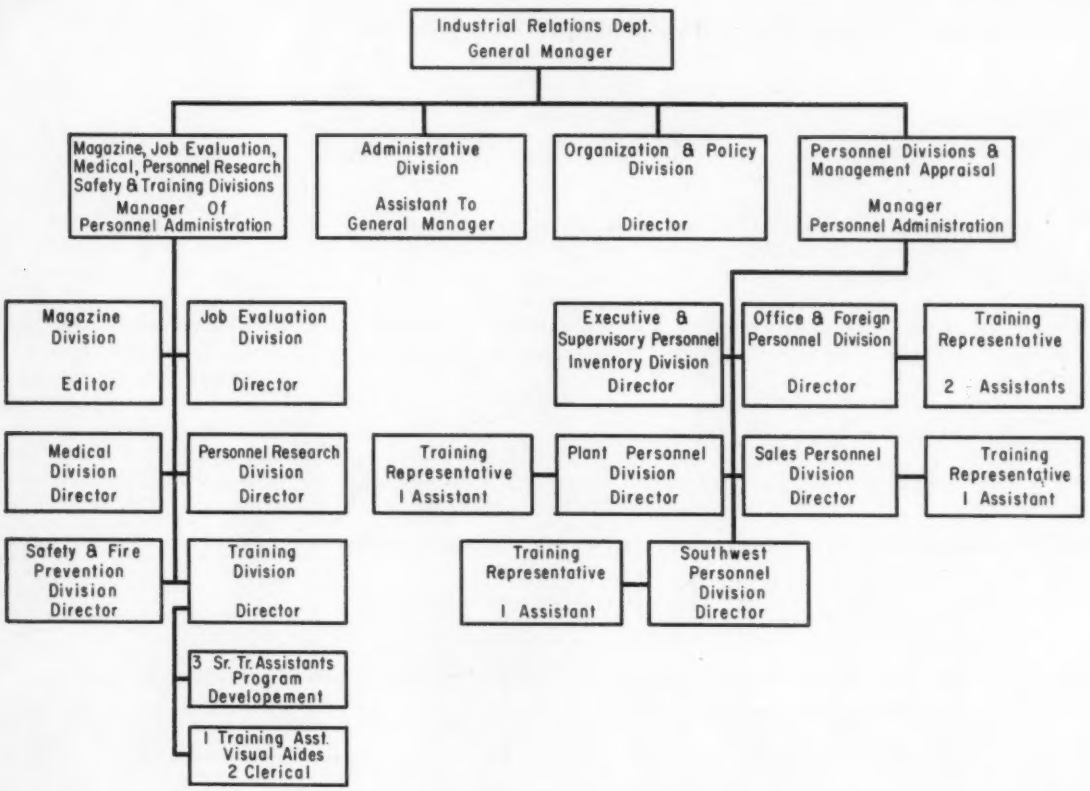
The second study was an investigation of how the 27 companies that have central training sections organize and operate them.

Here are the questions asked and the results of the findings:

How is a central training section organized and operated?

Central training sections vary in form from one company to another. The trends might be sunmmarized as follows:

1. The training director is a staff member and ranks with about three other assistants to the personnel vice president or manager.
2. Two or three departments or sections in the company do not coordinate their training through the training section, but management hopes to effect hundred percent coordination at some future date.



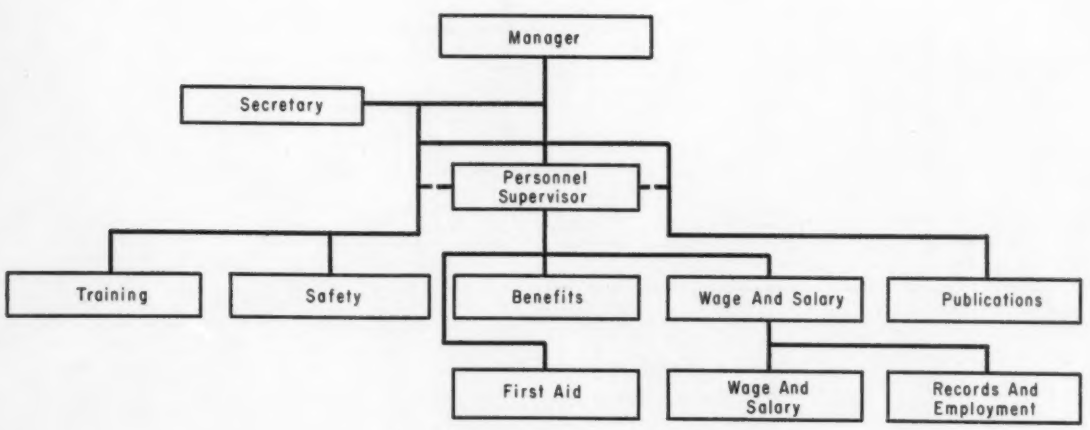


FIGURE 2—Shown above are organizational charts for

3. Training is the responsibility of line management.

4. The training section performs a staff function, assisting line managers by:

- **Advising**
- **Assisting**
- **Coordinating**
- **Evaluating**
- **Planning**
- **Teaching**
- **Testing**
- **Training trainers**

5. Current efforts to train people in the art and science of instruction are extremely limited.

6. Significant progress is already made, but management hopes to improve the company's training facilities and strengthen its training section.

7. Training is struggling to become a profession.

Figure 1 is the organization chart of an imaginary company. It shows exactly what is meant by "line" and "staff" and how training specialists would fit into a line and staff type of organization.

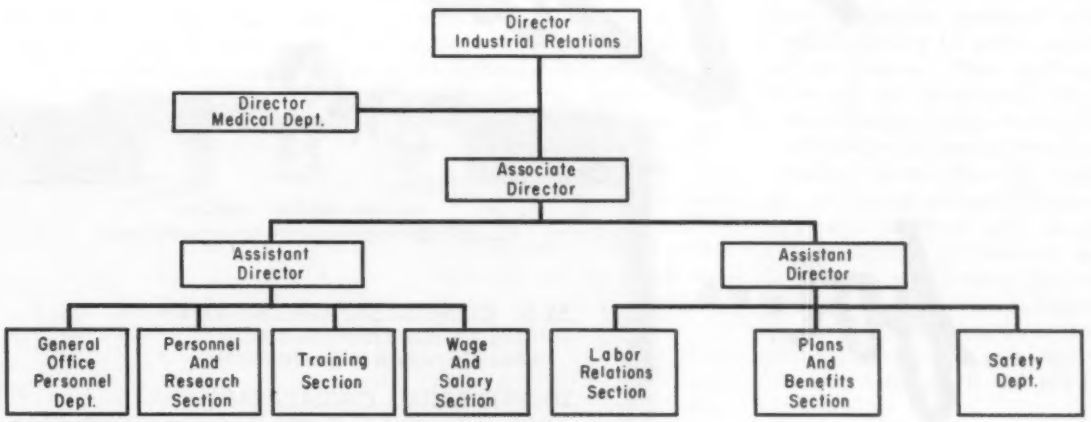
Figure 2 gives the organization charts of the personnel departments of four actual companies chosen at random.

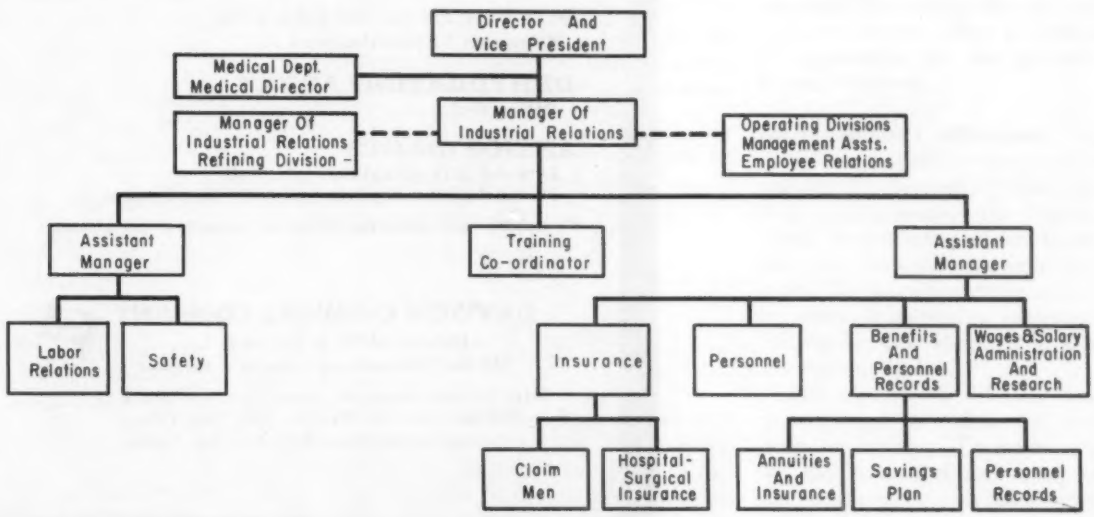
Each firm has its own means of trying to achieve a concerted training effort. These include:

- Regular reports of training activities submitted by branches or outlying locations.
- Plant or field visits by training people and general office executives.
- Year's plans and training budgets submitted for approval by central line executives.
- Periodic meetings of training people.
- Training projects in which field or plant personnel come to headquarters for training or training specialists travel to field locations.

In one company, supervisors originate all training by asking help of the training section. In another, the training staff takes the initiative. It trains the supervisors, maintains training records on them, plans and coordinates the training courses for the supervisors, actively assists the supervisors in their employe training and takes responsibility for supplies and equipment.

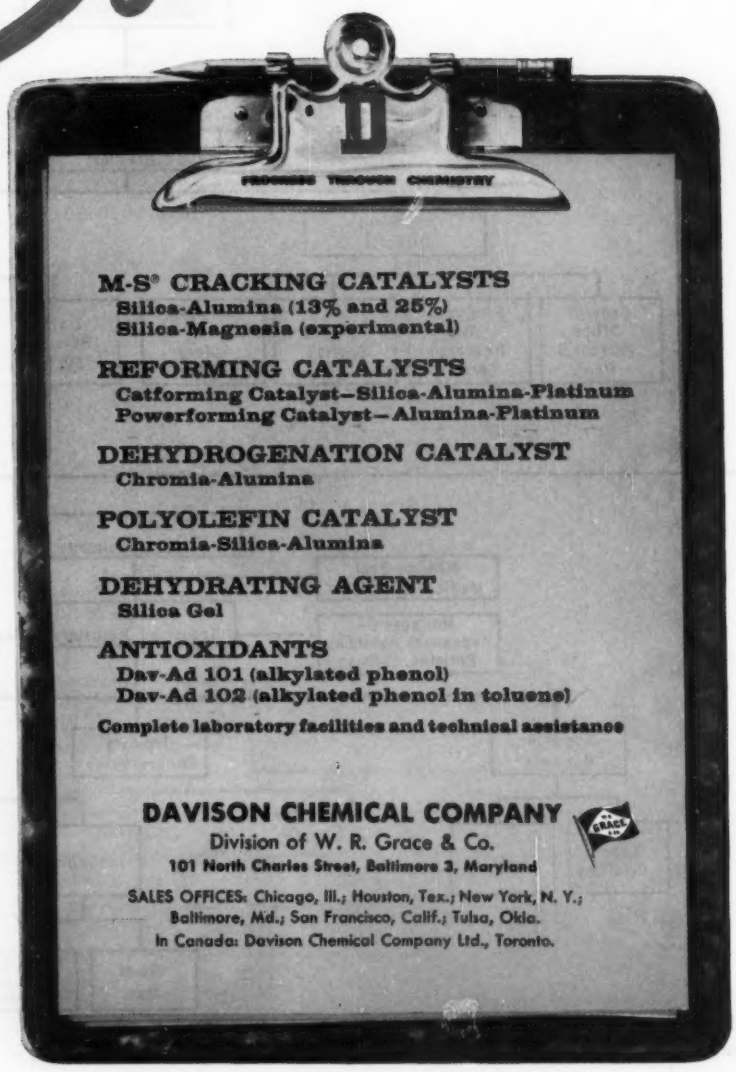
Generally, industry is trying to expand and improve its training facili-





industrial relations departments in four oil companies.

Refinery men depend on Davison for...



ties. To do so, it is widening the influence of its training sections.

A central training section may operate in different ways, such as:

1. Courses taught by representative of the training section.
2. Training conferences organized and conducted by the training section, but in which much of the actual training is done by conferees.
3. Courses promoted, planned, and coordinated by the section, but in which a line supervisor or other local person does the actual teaching and conducting.
4. Courses (as in Job Know-How) handled chiefly by the local supervisor with help from the training section in materials, advice and other staff services.

There are many combinations and variations of the above avenues of attack. The enterprising company fits its plan to the problem.

The majority of companies still do not have any instructor development whatsoever. But nearly all express the intention to do something along this line in the future. One of the major trends of the next few years may well be more training for training.

Are Central Training Sections Paying Their Way?

The case for the central training section can be summarized by saying:

- Consolidation creates efficiency.
- The bigness of the training activity creates a need for able control.
- The complicated personnel problems of modern industry demand abler training specialists.

Consolidated Purchasing. In one sense, buying training is like buying materials. Through consolidating, a company can avoid duplications, assure more even distribution, and obtain better commodities at a saving. Companies having central training sections claim that they:

- Obtain better qualified training specialists.
- Avoid duplication of facilities such as classrooms, projectors, film strips, mechanical trainers and printed materials.
- Establish a common basis for:
  1. Maintaining emphasis on good training for all employes.
  2. Determining training needs throughout the company.
  3. Evaluating training results in all departments.

A training specialist, qualified in the techniques of instruction, can give valuable assistance to instructors regardless of the subject matter. A man with such educational background is not available for every job location. It is better to have one capable training specialist go from department to department than to have a number of unqualified people do training work without guidance.

Cradle to the Grave. Employe training is expanding in all dimensions, including its span of years.

One company has a popular program called "Science for Youth." Teen-age sons and daughters of employes meet at the plant to follow their various scientific interests. The company (D-X Sunray) furnishes instructors and laboratory equipment.

For many years industry has provided summer employment to college students as day laborers. Now the emphasis is less on the immediate work accomplished and more on training for possible employment after graduation. On-the-job training and university courses are fitted together in a meaningful pattern.

Many companies now train older employes for retirement. Their purposes are to make happier and more useful citizens of annuitants and to build goodwill.

So people are trained before employment begins and in preparation for life after employment ends.

Suppose we describe briefly the amount and variety of training activities in order to visualize the task faced by training directors.

For simplicity, the subject can be divided into five classifications.

1. Job Know-How
2. Human Relations
3. Safety
4. Policies and Procedures
5. General

Under these five headings are myriad courses. Some are: Basics of Supervision, Modern Management Practices, Basic Economics, Orientation, Counseling, Procedures, and Maintenance Techniques.

The extensive proportions of training activities constitute one of the training sections's gravest problems. It must:

1. Turn most of the actual teaching over to men who may know their jobs well but cannot impart their own enthusiasm and skills to others.
2. Attempt to do all the teaching—which it cannot do.
3. Teach others to teach.
4. Do some of the teaching and develop instructors for the rest.

Wanted, Social Scientists. The training specialist needs a strong academic background. Whether gained in university or through private study, he should have extensive knowledge of training methods, psychology, and other social sciences. This demand for higher professional standards is born of industry's need for skilled employes and able leaders. These have to be discovered and developed. The discoverer-developer ought to be a dedicated student of human behavior.

During World War II, brilliant men developed serious neurosis because their sergeants were incapable of understanding and making use of the best that was in them. Sometimes the sergeant was the less intelligent of the two. By transferring them to more challenging work, the men, and their countries, were given the gift of a useful life.

Likewise, executives are taking a second look at their own file clerks and section heads, foremen and laborers. Boring through the shale of supervisors' limitations, they give talent a chance to flow. Here lie rich sands of opportunity for the specialist in human resources.

Management's Dilemma. Supervisors and executives not only need training for themselves. They rely on it as a management aid. Pressed between technological demands on one side and human limitations on the other, the supervisor looks about him for ways of increasing individual effectiveness. One means is to sharpen his teaching ability.

The supervisor's dilemma has led management to realize the need to train for training. To teach men the art and science of instructing others can be done by only those specially educated for it.

Business requires a higher calibre

of management today than ever before. The old types of leadership are not adequate: Too much depends on too many, too far away. There are deals and decisions that cannot be covered by printed manuals. The remote supervisor in the far flung reaches of a large company needs a built-in communication system tuned loyally to the interests of management and sensitively to the needs of all his employes.

The good supervisor or executive:

1. Knows his job.
2. Understands the human-social-industrial community within his company.
3. Imparts skill and knowledge to others.

These abilities can be enhanced through training. But this brand of uplift is the task of an educator.

What Companies Are Doing. To meet these increasing demands, many companies are:

1. Turning to the central training section as an agency that can devote its full time to training and divide its interest impartially between all employes.
2. Expanding their training sections to coordinate the training of all departments.
3. Employing training specialists with broad professional backgrounds in training methods, psychology and other social sciences.

The trend toward centralization has appeared good. All companies that created training sections reported that they were pleased.

But the task cannot be left to the tool. And the human task grows and changes. # #

About the Author

CARL M. WHITE is a training specialist who has had an almost lifelong interest in the many phases of training. He received his B.S. degree in business administration from Northwestern University and his M.S. degree in industrial psychology from the University of Tulsa. He is an educational advisor to the Air Force Reserve, and is continually promoting expansion and improvement of training facilities within his own company, Service Pipe Line Co. During the past three years he has been conducting a research program on the training practices of the petroleum industry. This has been done with the cooperation of the Psychology department of the University of Tulsa, the Industrial Society, and representatives of 50 large oil companies.

As Management Sees It . . .

How Do Your Public Relations Rate?

Here is an excellent yardstick to use in evaluating the success of any refinery public relations program.

Paul Lockwood
Richmond, Calif.

SOME REFINERY executives think of public relations in much the same way as they do their fire station . . . to be called when there is an emergency. Public relations—good public relations—is preventative medicine, not the doctor or the undertaker.

What is public relations?

Even today public relations is a mystery to many businessmen. Some, for instance, consider it a high science. Others think of public relations as printed publicity. Actually, public relations is just good common business sense in the way a refinery conducts its business with the public. The things you and your employes do and say molds public opinion—good or bad—about your refinery.

You cannot go out and buy a gallon or a barrel of public relations. It is not for sale. You and your organization must create it. You must plan it. And, you must work on it to make it a success.

Here is a check list of the elements that go into making a successful public relations program for your refinery. Check each of the points listed that you can honestly answer with an unqualified "yes." Then, add up your check marks, multiply by two, and you will have the score for your refinery's present public relations. If you score 90-100, you are public relations minded. If you score 80-90, some improvement is needed. If you score below 80, some earnest public relations soul-searching is in order.

PUBLIC RELATIONS CHECK LIST

Civic Responsibility

__Do you belong to organizations in your community in each of these classifications—church, lodge, service club?

__Do you take an active part in at least one of these organizations of which you are a member?

__Are you a strong supporter of programs designed for the civic betterment of your community even though there is no personal gain involved?

__Do you participate in the recog-

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- "Reliance®" Double Jacket Dacron reinforced (weighs 50 lbs. per 100 ft.) (withstands 400 lbs. test pressure)
- "Reliance" Double Jacket Dacron reinforced (weighs 54 lbs. per 100 ft.) (withstands 600 lbs. test pressure)

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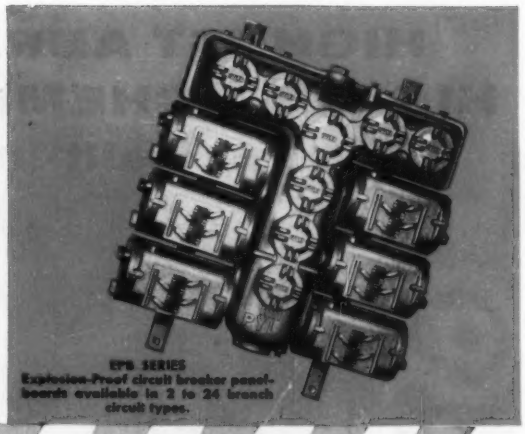

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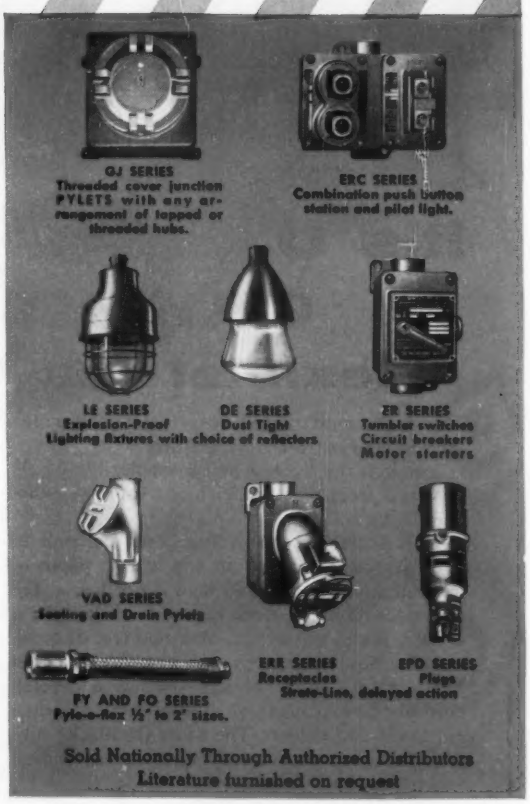

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nized worthy charity drives in your community?

__Do you contribute your business know-how, facilities and time to make every civic enterprise a success?

Personnel Relations

__Does your salary and employe benefit program compare favorably with other employer's plans in your community?

__Do you take a genuine and a sincere interest in your employes and in their problems?

__When it is necessary to discharge or lay off an employe, do you explain the situation completely to the worker?

__Do most of your advancements to better positions in your refinery come from within the organization?

__Do you keep all of your employes informed about the goals, problems and position of your refinery all the time?

Business Correspondence

__Do you answer all letters you receive as promptly as possible?

__Do your business letters have a pleasant, friendly tone that gives a true impression of your refinery?

__Do you personalize your letters so that the person receiving the letter does not feel "you say that to everyone."

__Is there anything in your letters that might have a different meaning than the one you intended?

__Does the physical appearance of your letters create the kind of impression you want people to have of your firm?

Telephone Technique

__When answering the telephone, do you have a "smile" in your voice?

__Do you introduce yourself and give your firm identification when answering the telephone?

__Do you make it a point to get your caller's name when you start talking on the telephone?

__Do you personalize your telephone conversation by using the caller's name while talking?

__Do you always answer your telephone calls as promptly as possible?

Advertising Attitude

__Do all of your advertisements fit into the character you want to create for your refinery?

__Are your advertisements prepared in good taste to give people a feeling of confidence in your business?

__Do you avoid the tendency to knock your competition in your advertising?

__Do all of your advertisements have some means of identification for your business?

__Do you avoid any misleading or semi-true advertising that will be a business boomerang?

Printed Publicity

__Do you know the publisher or editor of your local newspaper personally?

__Do you keep your newspaper informed of any personal or business activity that is newsworthy?

__Do you avoid the tendency to be a "publicity grabber" for any little thing that happens?

__Do you refrain from complaining about the amount of publicity you receive in comparison with other businessmen?

__Do you give the common place publicity about your firm a different twist to make it more interesting?

Handling Complaints

__Do you make every effort to handle all complaints and adjustments promptly?

__Are you fair in all settlements offered to your customers about their complaints?

__When you are at fault, do you quickly shoulder the blame instead of grudgingly making an adjustment for the customer?

__Do you live up to the spirit as well as the letter of all agreements you make with your customers?

__When dealing with a "chronic complainer" are you fair but firm?

Supplier Relations

__Do you make it a point to see and to examine the supplies and equipment of every salesman calling on you?

__Do you treat visiting salesmen as friends rather than as business enemies?

__Do you avoid any criticism of the supplies and equipment in the salesman's line?

__Do you offer constructive suggestions that might lead to some improvement of the supplies and equipment?

__Do you avoid all sharp-trading practices such as asking for unusual terms, faster delivery and special discounts?

Creditor Relations

__Do you pay all invoices as promptly as possible within the dating allowed?

__Do you take only the discounts allowed on the invoice instead of mis-interpreting the terms or datings?

__Are you fair in seeking credits and adjustments for the supplies and equipment you purchase?

__Do you re-check carefully on any errors that seem to indicate a difference in invoice amount and the amount received?

__When it is necessary to delay payment of an invoice for some reason, do you inform the supplier of the situation?

Credit Accounts

__Do you explain all your rules and regulations about your credit plan to your customers when the account is opened?

__Do you handle poor credit risks in a tactful manner to avoid any ill will with other customers?

__When obtaining credit information from a customer, do you make sure that the questions you ask are not embarrassing?

__When following-up overdue accounts, do you have a system that still holds the good will of these slow paying customers?

__Do you give your customers every opportunity to make some plan for settlement before taking drastic action on your charge accounts?

These 50 questions will give you a cross-section of your public relations program. All are important to the future success of your business and all have a bearing on the opinion the public will have of your refinery. By applying good common business sense to any areas that show a weakness, you can improve your public relations in your community. ##

Controlling High Vapor Pressure Fires

A top authority on fire protection outlines the 'do's and dont's' of storing high vapor pressure products.

J. L. Risinger,
Fire and Safety Consultant
Maplewood, N. J.

A NEWS REPORT told of a tank vent fire which split open the roof of a tank, spraying burning oil on voluntary firemen.

Investigation revealed that a high pressure storage sphere was placed in a depression so spillage could accumulate. On top of the sphere, the large vent had two crooks pointed downward toward the dome so that a vent fire would play a blow torch-like flame on the dome above liquid level.

Some 250 feet from the sphere a flame burned under an asphalt container to heat the product so it could be pumped. The vent fire was not a regular vent fire on a cone roof tank but a vent fire on a sphere containing at the time aviation gasoline. Since, however, the vapor pressure of any product is dependent upon the temperature of the oil, the vapor pressure was high at the time from heat around the sphere.

The sphere was not equipped with water spray or ring to be applied either automatically or manually, and emphasis had not been placed on the importance of cooling water in case of fire around these spheres.

The order of events leading up to the explosion were as follows:

1. Leakage spilled the high vapor pressure product in the depression around the spheroid.
2. The vapors from this leakage traveled to the flames under the asphalt tank.
3. These vapors flashed back to their source, the accumulated high vapor pressure product at the base of the spheroid, and the sphere was thus in a fire pot.
4. As planned, when the sphere was heated, the vents at the top of the sphere opened up and caught on fire.
5. These vents being turned down started a blow torch flame on the dome of the sphere above the liquid level, and there was no liquid inside at that point to conduct the heat through the steel into the oil, thus the steel began to become very hot and weaken, just as would an aluminum pan on the fire without water in it.
6. Voluntary firemen came to the scene and devoted their attention to fighting the big fire around the spheroid.
7. The vent functioned to relieve the pressure to an extent that the strength of the steel of the sphere would have withstood the pressure. However, the steel, heated almost to the melting point by the blow torch effect at the top of the dome, was not strong enough to withstand this pressure. The dome ripped open pulling the steel to a thin melted edge at the break.
8. Liquid spewed out as from a tomato can placed on the fire and the hot heavy burning ends of the product dropped out of the atmosphere onto the people.

In the construction and operation of this spheroid, several seemingly small items were overlooked. They were obvious after the catastrophe occurred. The three chief errors, the avoiding of either one of which would have prevented the catastrophe included one in layout, one in design and construction and one in fire fighting. These corrective measures will be found under the headings mentioned.

About 10 years ago, a large spheroid was involved in a fire. The rise in temperature raised the vapor pressure. The fire against the shell above the liquid level weakened the steel. The sphere gave way and a part of it weighing many tons landed on the dike surrounding another sphere, providing a fire around it—and it also ruptured.

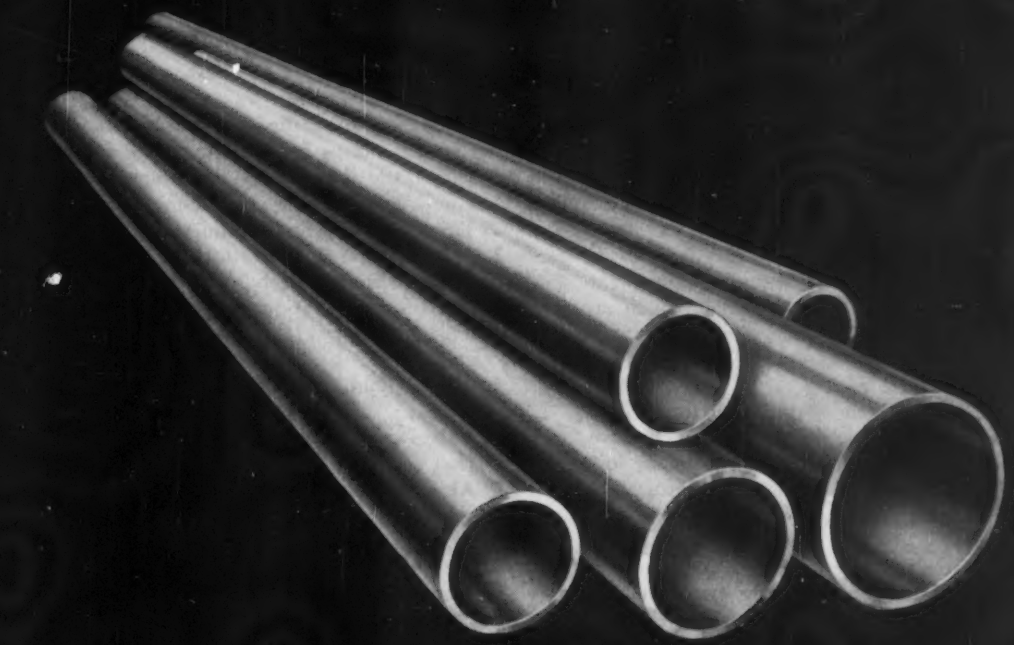
What occurred in this case was as follows:

1. Several spheres almost a mile from refinery units were placed in depressions with high dikes around each.
2. Pumps and lines were located in the dikes with pump almost under the large sphere.
3. The spheres were on supports.
4. There was no water spray or ring installed to keep the tank cool above liquid level to prevent weakening of the shell above liquid level.
5. Excess pressure vents on the spheres were at low capacity.
6. The product in the sphere had an RVP of about 16 pounds per square inch.
7. The sphere was filled to about 50 percent capacity.
8. A leak occurred, and the rapidly evaporating product accumulated around the sphere.
9. The vapors overfilled the dikes and the cloud of accumulated vapors drifted to a switch engine some 600 yards away. It was ignited, and the fire flashed back to the source, the spilled liquid around the sphere. No one was injured in this fire as the refinery manager, recognizing the hazard of these spheres involved in a fire, cleared personnel out of the danger area.

On another occasion a butane line broke and was playing a jet of flame on a tower. Trained firemen quickly directed a stream of water on the tower at the spot and kept this water stream so directed for the duration of the fire, which was until the flow could be cut off and thus the flame stopped. In this case nothing occurred.

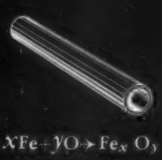
In another case almost identical with this one, no water was directed onto the tower at the spot where the flames were playing. The tower was heated to a point where the supports were weakened, and it turned over spreading the fire and causing several fatalities.

These stories could continue with descriptions of spill-

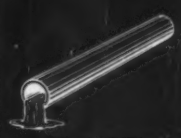


PRESSURES

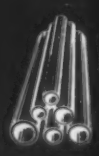
TEMPERATURES



OXIDATION



CORROSION RESISTANT



SIZE

At B&W—You Can Get - - - The Right Tube For The Job

Pressures, temperatures, oxidation, corrosion resistance, and tube size are important factors the design engineer must consider in specifying tubing for process equipment applications.

For example, one company was faced with a serious problem. Stainless tubing used for conveying methanol and unreacted synthesis gases at 300F and 5000 psi through chloride-bearing bayou water failed due to stress corrosion.

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Just what many other companies have done—they called in Mr. Tubes, a B&W Tube Representative. He suggested B&W Croloy 5 as the best material for the job.

The new tubing provided the desired resistance to the particular type of corrosion and satisfactorily met all temperature and pressure requirements. What's more, the new installation proved to be substantially lower in materials costs.

B&W, with its years of experience in all phases of tube requirements, is especially qualified to help you choose the right tubing for any job. To get the most benefit from B&W's long experience in matching tubes to jobs in every respect, call on Mr. Tubes, your nearby B&W Tube Representative. He has helped others, as he can help you, make tubing selection *surer*. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

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age and fire around containers of high vapor pressure products.

Know Your Product Characteristics. The many experiences that could be related do not condemn these products as uncontrollable hazards to life and property. They do emphasize the importance of measures of control of these products in accordance with the characteristics of the products.

The products stored in spheroids may vary from aviation gasoline with a Reid Vapor Pressure (pressure at 100° F.) of from 5 psi to 7 psi; motor gasoline with an RVP of from 7 to 12 psi to products that remain in liquid state only under pressure or at a very low temperature.

The chief use of spheroids, however, is for the storage of such products as butane and propane which have RVP vapor pressures ranging from 15 psi to in the low 20's. Liquefied petroleum gases are usually mixtures of butane, propane and other gases in accordance with the climate in which used.

In handling and storing these gases it is important to remember that they are approximately two times as heavy as air. They will settle in low places, travel along depressions, sink down into openings in buildings and settle in pump locations if pumps are below ground level. They will travel farther before being dissipated than will vapors from open surfaces of gasoline and other lower vapor pressure products.

Vapors from gasoline are formed by contact with the air. The gas cloud formed when butane pressure is released is pushed along by a current of air for great distances before becoming sufficiently diffused as to be too lean to become ignited. It is to be kept in mind that when containers are filled with these very high vapor pressure products, they are kept in liquid form by their own vapor pressure. The flashpoints of these products are too low to be of significance in their description.

When a sphere, cylinder or tank of these products is involved in a fire around them, the pressure rise is such that sometimes even very extensive venting will not relieve it sufficiently to overcome any weakening of the steel above liquid level. Thus it is very important that spheres or tanks containing these products be so plotted that neither the product itself nor spillage from other tanks of any kind of oil will accumulate around them.

Layout and Design. A few suggestions are here offered to lessen the probability of the high vapor pressure product container becoming involved in a fire that would build up a pressure beyond control.

1. At installation, give consideration to ample clearance between tanks and between tanks and property lines.
2. Place regulators etc. well out of tank fire area.
3. Place pumps and connections so that leakage or spillage from breaks will not accumulate or flow under spheres. Often diversion walls or levees of earth are necessary. (Pumps should not be under tanks if it can be avoided.)
4. Provide for rapid evacuation of spillage that might occur under spheres. Sloping grade for channeling or other means, and a location to which products will drain or can be washed and trapped, or permitted to burn at a safe location, is imperative both for prevention and control of fire and explosion.
5. There should be no low spots under or near the base of the container where spillage could accumulate and place the container in a fire pot.

Design and Construction

A. Close check on suitability of materials and equipment prior to and during installation and when any repairs are being made, is of extreme importance.

1. Use of high melting point alloys or steel.
2. The use of steel and welding for piping.
3. Avoid the use of small stuff like ¼ inch. Anything under ½ inch is likely to be flimsy.
4. Allow flexibility and room for heat expansion, also for relief of liquid trapped between closed tank valves.
5. Suitable pumps to withstand service and exposure to heat.
6. Valves capable of withstanding pressure and heat (not cast iron or brass).
7. Although there is no case on record of a tank or spheroid rupturing below liquid level when involved in fire, more attention to bottom strength than to top strength is suggested, to prevent a first time.
8. Coat columns supporting spheres with the proper thickness of some fire resistant material such as concrete, which will enable the supporting members to withstand the intense heat over a reasonable time without collapse.
9. Install well-screened water spray in suitable volume. Galvanized pipe should be used. Have water pressure available at all times for the spray nozzles on the tops of these pressure storage tanks, and also make arrangements so that the water can be turned into the system from a number of remote points. The extensiveness of this system should be determined by value of other properties exposed.
10. Turn vents upward, or to the side. Never so construct them that in case of a vent fire a blow torch of burning vapors or gas will play against the tank above liquid level.
11. Adequate pressure relief is of major importance. Two suggestions have been offered for relieving excess pressure which is difficult to take care of by safety valves:
    (a) A rupture disc arrangement whereby the released gases are piped to a safe location and there burned.
    (b) Manually operated relief, remotely located on main vapor line.

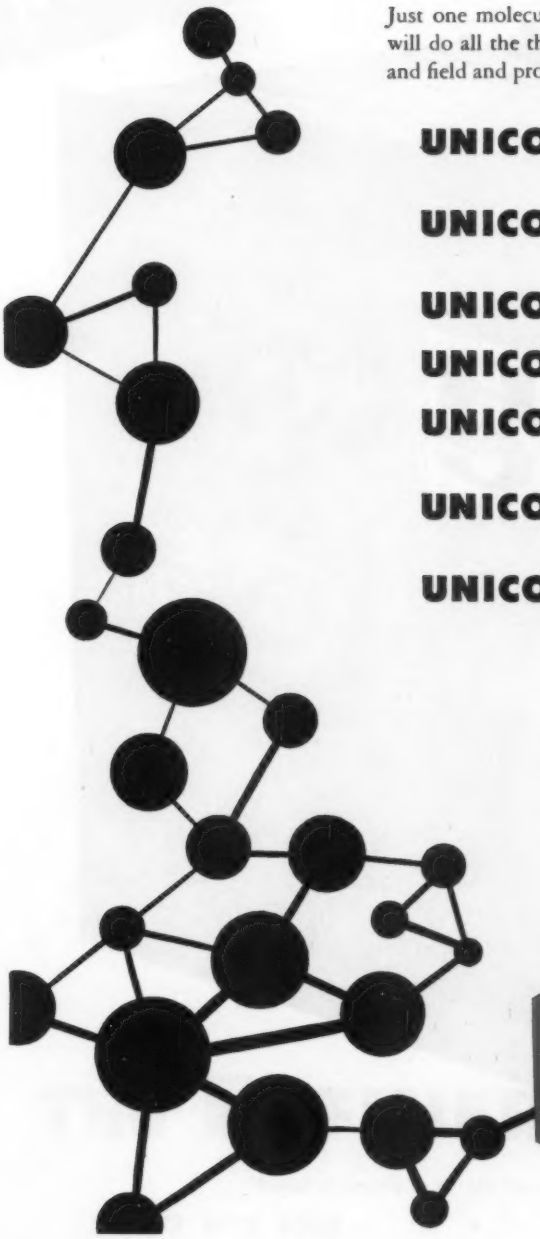
B. Provisions should be made for cutting off the flow of the product in case of break or leak.

Steel checks on separate fill lines placed close to the valve on the tank nozzle may be of benefit in case of line breaks. Thermally operated valves on outlets will also be of benefit. This refers to bottom outlets below the liquid level. Manual means to release pressure by opening a valve on the top vapor line at some remote point is desirable.

Double valves should be provided on draw-off lines leading to atmosphere or to open containers from storage vessels containing butane (or lighter products) under pressure where the character of the stocks and magnitude of the pressure might result in appreciable refrigerating effect if the pressure is suddenly released.

It has been suggested that all valves located under

1 in a million!



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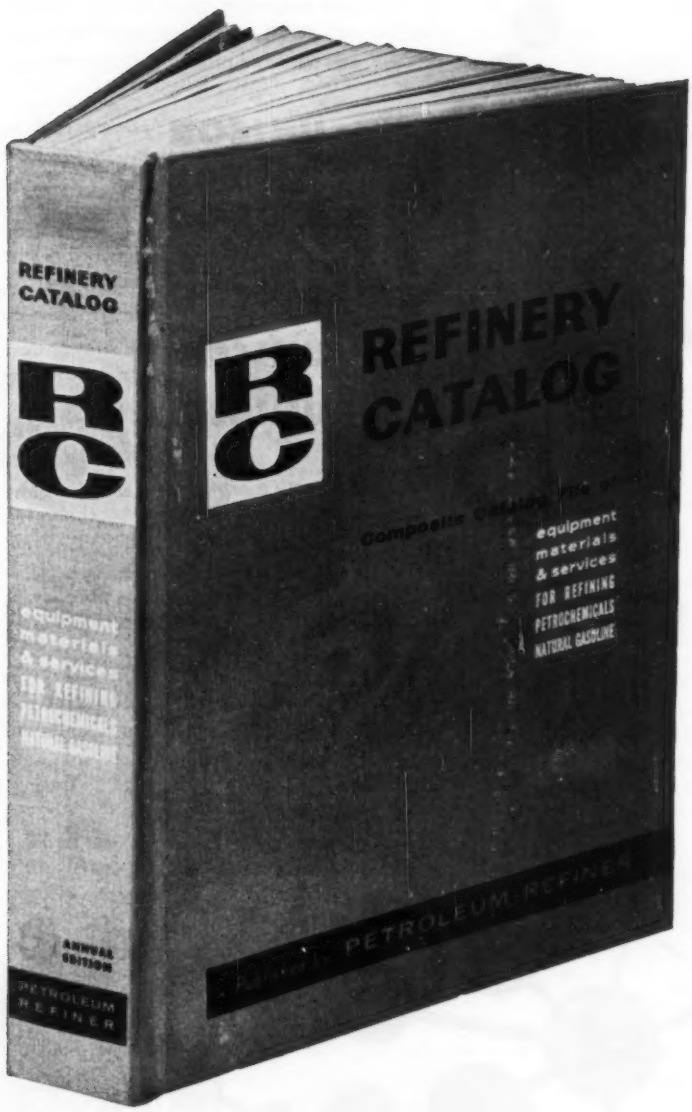

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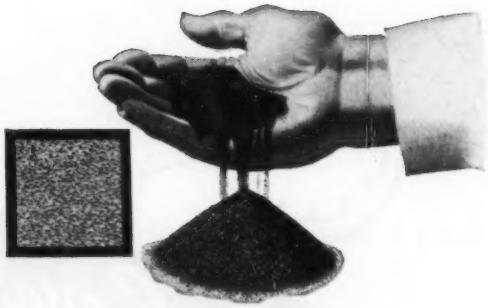
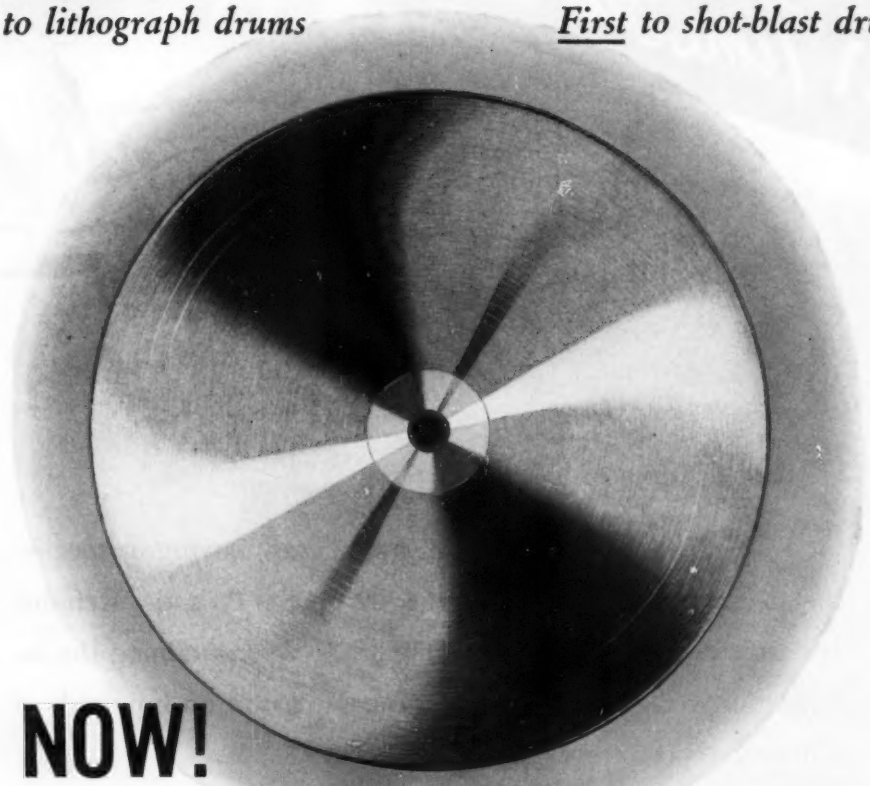


First to shot-blast drums



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these tanks be equipped with extension stems through any diverting walls, in order to close them off in case of emergency.

C. Operations.

1. Maintain constant watch against leaks, cut off the flow to them as soon as possible and correct the damage, taking no chances on exposure to flash.

2. Care must be taken to prevent overflowing the sphere or other container, since the liquid released from the safety valve will form a large volume of vapor which can travel a considerable distance.

D. Fire Fighting.

1. Open container and spill fires in a large quantity of high vapor pressure products, such as carried in spheroids cannot be extinguished by any fire fighting agent or device now known. Furthermore, if such a fire could be extinguished, to do so in most cases would create greater hazards than the existing fire itself, since the unburned vapors might accumulate at other locations.

Therefore, the most effective means of controlling fires in these products is to use plenty of water to keep exposed property cool and shut off flow of product to the fire.

2. Play as much water on the container above liquid level as possible. Even if water spray or other means of water application is fixed, play heavy streams of water on exposed steel above liquid level if this can be done without depleting the water supply.

3. If vent or broken line is playing blow torch flame on steel above liquid level, direct streams of water on this spot. If this can not be done quickly, stay clear of rupture of the container which is almost sure to occur from heat weakening of the steel. Water is very effective in cooling steel in such cases.

4. By all means protect the container above liquid level. It is conceded that a low viscosity product will conduct heat away from the shell of a spheroid faster than would those of high viscosity. The claim that in such products as butane, when heat is applied to the outside of the shell, that a vapor layer is formed next to the shell, thus interfering with heat transfer, is somewhat offset by the fact that there will be a condition of tuburlence.

In any event, there is no record of a spheroid rupturing below the product level when heat is applied to it. The rate of this transfer, as it affects vaporization and formation of pressure when determined, will give a clue to the capacity of excess pressure relief needed. The value of water spray cooling and the providing of ample excess pressure relief is emphasized.

5. In the case of a broken line or other such leak, do not extinguish the fire except by shutting off the flow.

It is sometimes feasible to extinguish the fire and then shut off the flow. Fires of considerable sizes can be extinguished by use of dry chemical extinguishers. On large fires of this kind, water fog of spray should be used to protect the approach and cool steel or extinguish wood and rubbish fires against reignition of the gas before source of flare of gas can be cut off.

If flow is not cut off, vapors or gas may accumulate and then when re-ignited the flow will travel back to its source.

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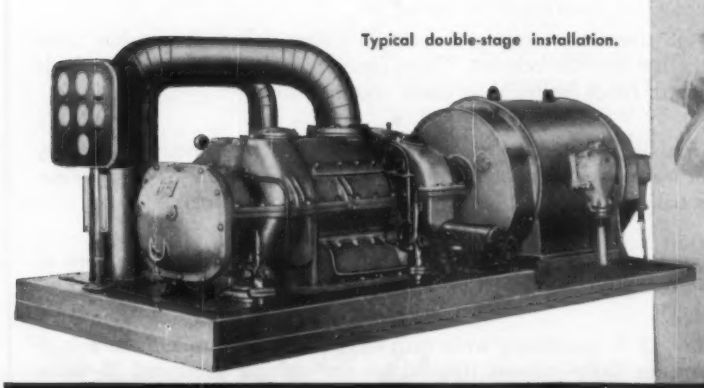
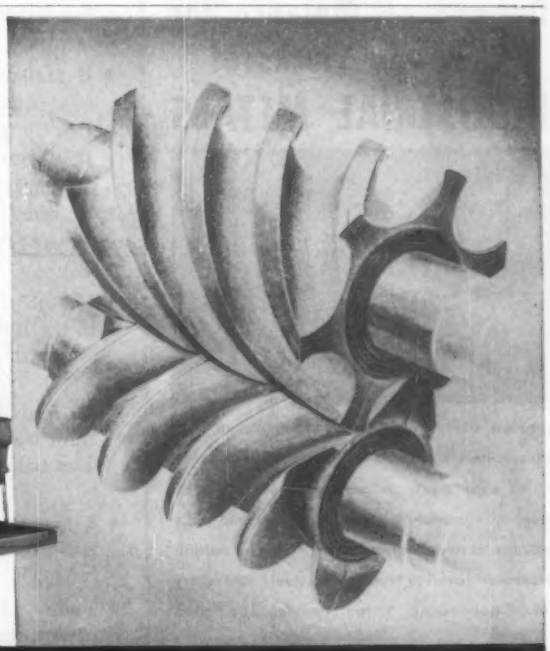
for oil-free handling of air and many other gases. Flow rates range from 350 to 15,900 cfm. Pressures up to 155 psia.



Typical double-stage installation.



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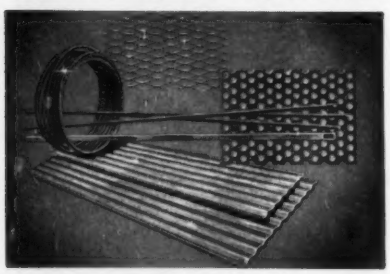

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If oil could speak it would have many fascinating truths to tell the non-oil public—truths that would win thousands of new friends for the oil industry.

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Read these facts. You will find them informative—and interesting.

"If Oil Could Speak" it would tell the American public:

•

- Last year, gasoline-driven vehicles of all kinds traveled a distance equal to 31 round trips to each of the eight other planets in our solar system, with a few billion miles left over for detours.

•

- Ninety-five percent of the 65 million meals served daily in public dining rooms are cooked with natural gas.

•

- The drilling rig, often as high as a 15-story building, is so skillfully engineered that it can lift and lower equipment weighing as much as five locomotives.

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- If present trends continue, 25 years from now our petroleum needs will equal the lifetime output of an East Texas oil field every year. But the present rate of oil exploration and discovery shows that the petroleum industry can meet this need—and more.

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- By reducing wear, modern, high-quality motor oils can triple the life of a car engine.

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- The 48 states have collected over 26 billion dollars in gasoline taxes in the last quarter century. These funds have been the greatest single source of funds for building roads and highways.

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- More than 3 billion gallons of petroleum fuels were used last year by farm tractors alone. The greater portion—83.7 percent—was gasoline. The balance was comprised of kerosine and other fuels.

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- A new service station road map usually represents an investment of more than $20,000 before a single copy is printed for distribution.

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- Today, U. S. producing wells turn out more than 6 million barrels of petroleum daily—almost three times the volume produced 25 years ago.

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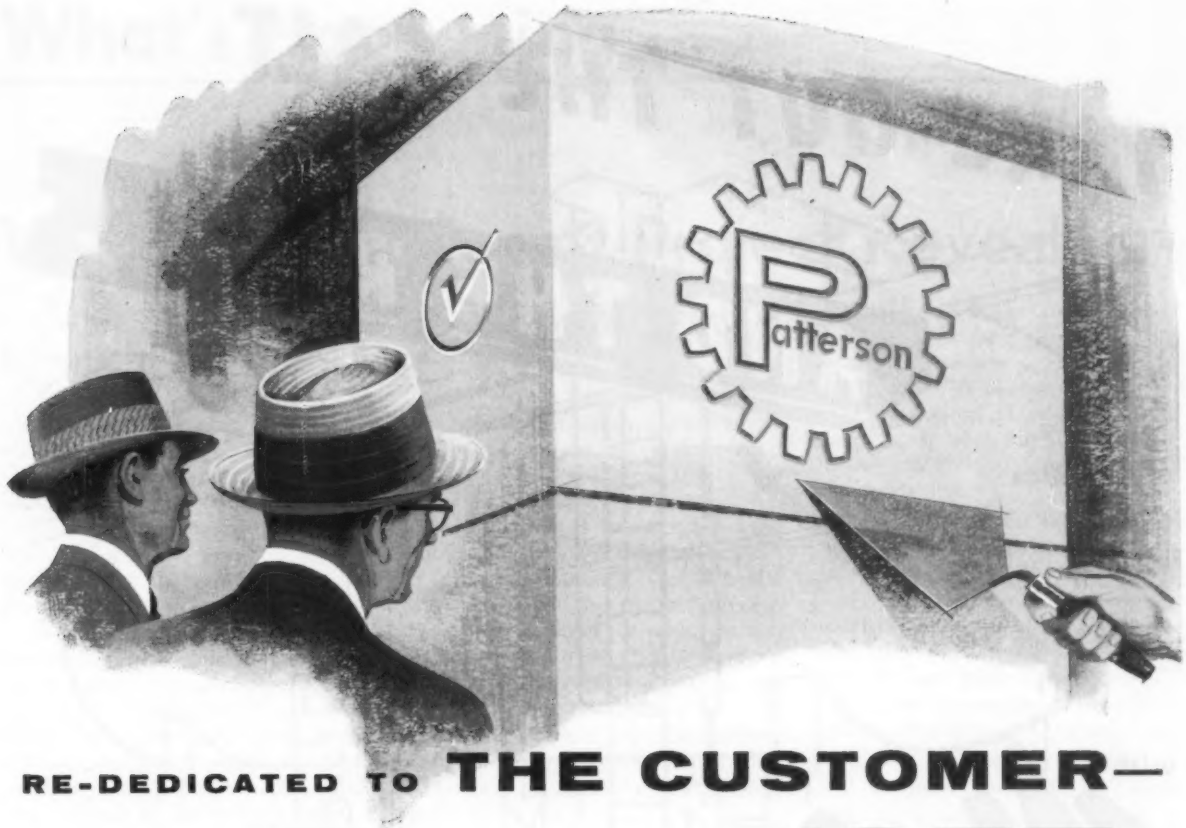
- In just 25 years, total mileage of petroleum product pipe lines jumped more than twenty-seven-fold—from 1289 miles to 36,735 miles of pipe line.



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What's Happening . . .

. . . in the Industry

World War II Secret Project Revealed

Indiana-Standard breaks 14-year silence to tell its role in developing first atomic bomb.

With the unwrapping of a 14-year-old World War II secret, Standard Oil Co. (Indiana) has revealed original technological contribution it made to the wartime Manhattan District—the gigantic scientific and industrial effort that produced the first atomic bomb.

Joseph K. Roberts, vice president of research and development, said that in 1944 and 1945, working under the most rigid secrecy, the company's research department built and operated a unique distillation plant for quantity production of boron-10—one of the two isotopes of the element boron.

Significant property of boron-10 is its ability to absorb neutrons, nuclear particles essential in an atomic reaction, he said.

Only now, however, has information on the secret project—known only as No. 4 process laboratory—been declassified by the Atomic Energy Commission.

Back in December of 1943, A. L. Conn, now director of the process division of the company's research laboratories at Whiting, Ind., was put in charge of the boron-10 separation project. Conn recalled that the company undertook the $2.3 million job at the request of Maj. Gen. Leslie R. Groves, head of the Manhattan District. General Groves chose Standard because of the company's knowledge of, and experience with the kind of complex distillation techniques that would be needed to produce the isotope.

Boron-10 had never before been produced in commercial quantities. Only the probability that it could be produced had been established previously in the laboratory by Dr. Harold C. Urey and his associates at Columbia University.

The plant, consisting mainly of nine distillation columns up to 50 feet high, was set up in an unused boiler house in a remote area of the Standard Oil refinery at Whiting.

Its end product was a water-white liquid from which a solid—the metallic form of boron-10—subsequently was recovered by another process. Daily production of the plant was two gallons of the liquid. Of that amount, about nine percent ultimately was converted into the solid.

Metallic boron-10 recently has been valued at more than $100 an ounce.

Security regulations were stringently enforced at No. 4 process lab., Conn. said. "For the most part, we told each person in the project only what he needed to know to carry out his job. Of the 280 persons who worked there, only about 25 technical people knew exactly what the plant was producing and how it was being done," he added.

Conn recalled that no one in the project ever was told the purpose of the Manhattan District. It wasn't until this project was mentioned in connection with the atom-bombing of Hiroshima on August 6, 1945, that he knew for sure what its mission was.

Was the boron-10 produced at Whiting during the war actually used in the first atomic bombs?

"I honestly don't know," Conn said. "All we can do is speculate."

AEC technician prepares to load a 3-ton lead 'pig' containing 3 pounds of radioactive cobalt.

Cities Service Receives Cobalt Shipment

With a potency two and one-half times the world's supply of radium, three pounds of cobalt have been delivered from the Atomic Energy Commission's Brookhaven facilities at Upton, Long Island, to the radiation section of the newly-constructed Cities Service Research and Development Co. laboratory at Cranbury, New Jersey.

The cargo of silvery white metal, made artificially radioactive in the reactor is the largest shipment of its kind ever to leave Brookhaven. For

What's Happening. . .

its journey, the metal was encased in a three-ton protective shield of lead.

Cities Service scientists will use this source of nuclear energy as a tool in a long-range research program. The investigations into the unknowns of petroleum science will add to the store of knowledge being accumulated on the effect of nuclear energy on various petroleum chemical reactions. Gamma rays have the highest penetrating power of any rays associated with nuclear energy and will first be used for certain specific applications. The effect of nuclear radiation on the improvement of various types of refinery processes will be studied, as well as the effect on existing fuel and lubricant products.

At the Cities Service laboratory, the irradiated cobalt was placed in a cave located in a specially-constructed concrete room, with a safety factor ten times that required by the Atomic Energy Commission. The 42-inch-thick walls of the room are made of high-density concrete, and a specially-constructed door to the cave is made of 12-inch-thick lead. It weighs 15 tons.

Remotely-operated air motors will be used to handle the stainless steel pipes containing the radioactive cobalt. The cave has a monitor to indicate the level of activity at all times. If this level becomes too high, safety devices make it impossible to open the lead shielding door.

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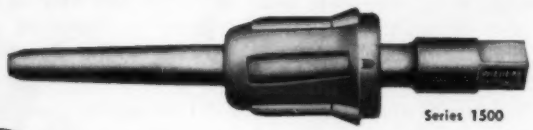

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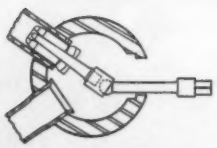
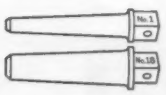
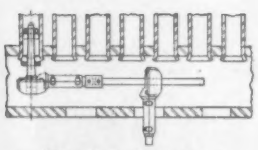


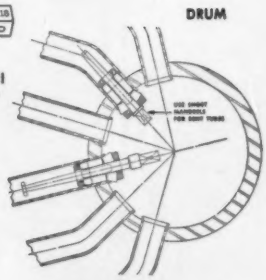
With Short Mandrel; Universal Joint Drive for Superheater Header.



Short Mandrels—all sizes, in 3 lengths



With Short Mandrel and Right Angle Gear Drive; for round or square headers.



With drum Mandrel for straight tubes; use short Mandrels for bent tubes.

#38

IDEAL

Continuous research and development in Tube Expanders, Tube Cutters and Operating Accessories for condensers and boilers has been going on at The Gustav Wiedeke Company since 1892. The IDEAL Trademark is your guarantee of quality. *Confidence* is your assurance that your job will be done *RIGHT* . . . when you use WIEDEKE Specialized Products. Wiedeke Distributors in principal cities. Write for *new* General Catalog 81.

The Gustav WIEDEKE Company

Dayton 1, Ohio

Observes 75th Anniversary

In 1882, twelve stockholders pooled their finances to acquire two refineries, a barrel factory and paraffin works. The new firm was named Standard Oil Company of New Jersey

In 1957, that same company is owned by more than 400,000 stockholders and its interests are spread throughout the world to form one of the world's largest oil corporations.

The colorful story of Jersey Standard's beginning, its growth and present status is described in an attractively illustrated 80-page "75th Anniversary" edition of the company's publication, *The Lamp*. Included in the history is a description of the role Jersey played in exploration, development and manufacture of the nation's oil from the kerosine era and gasoline age to development of new fuels of the future.

Also included is a chronological report on the contributions Jersey Standard has made to the industry and the world, i.e., the first commercial 100-octane gasoline was made at Esso Baton Rouge in 1935; butyl rubber was developed by chemists at Standard Oil Development Company; discovered a new process for producing synthetic toluene for TNT (1939); put first fluid catalytic cracking unit on stream at Esso Baton Rouge in 1942.

FTC Restrains Re-refiner

Federal Trade Commission examiner has issued an order restraining Double Eagle Refining Co., Oklahoma City, from misrepresenting as new, the reprocessed oil it sells.

The FTC charged that Double Eagle sells reprocessed oil in same containers used for new oil without disclosing the nature of the product. On the other hand, the company has responded by arguing that the oil meets all of the standards of new oil, therefore it is not necessarily bound by the identification rule.

Will Plea for Depletion

Colorado Governor Stephen L. R. McNichols will ask the National Governors Conference at Williamsburg, Va., this month to support a proposal to grant the oil shale industry the same 27.5 percent depletion allowance for federal tax purposes given petroleum producers. McNichols was recently elected chairman of the Western Conference for Governors, which endorsed depletion allowance for the oil shale industry.

U. S. Suing B. F. Goodrich

The Department of Justice has filed a suit against B. F. Goodrich for an alleged refusal to comply with the terms of a government research contract requiring disclosure to the government of a new synthetic rubber process.

A complaint filed with the U. S. District Court in Washington also involves Goodrich-Gulf Chemicals, which made public announcement in December, 1954 that it had developed a process for production of cis-1, 4-polymer of isoprene—assertedly chemical equivalent of natural rubber.

The Justice Department charges that in violation of an agreement with the government, B. F. Goodrich has applied for a U. S. patent on the process, and that

Memo: to all process engineers—

Why Tolerate Liquid Carry-Over?

...when METEX Hi-Thruput Mist Eliminators can deliver 100% efficiency!

● Whether it's on a vertical tube evaporator, a packed column, knock-out drum or a vacuum pipe still, there's no necessity, *today*, to permit poor liquid-vapor separation to pull product quality and profits down. With Metex, you have a unit that's *different*. Hundreds of thousands of openings and wire surfaces, so combined as to baffle uprising gas-liquid streams in multiples of thousands of physical separating contacts, can and *do effect complete gas-liquid-contaminant separation.*

No other unit delivers more efficiency, offers longer life or less maintenance. Used and specified by hundreds of process engineers, Metex Hi-Thruput Mist Eliminators are the standard of excellence wherever efficient entrainment separation is important to good production and profits.

• Write for Bulletin ME-6

METEX QUALITY PRODUCTS

• metal textile corporation

roselle, new jersey

Representatives in principal cities throughout the world.

7-072

What's Happening. . .

Goodrich-Gulf has already obtained a Belgian patent on the same process.

Justice Department said that in the event the suit is successful, the government will make the new process available to the entire rubber industry.

The government's claim actually arises from the World War II program of granting government funds for use by the rubber companies in developing synthetic processes. The Department of Justice said that B. F. Goodrich was under contract with the government from 1949 to 1955 to make available to the government all information within the scope of the research program. This was regardless of whether such information resulted from research paid for by U. S. The contract also granted the government a royalty-free license to use this information and disclose it to others.

Claiming that B. F. Goodrich has consistently refused to comply with the contract terms, the Justice Department is seeking a court order directing the company to deliver to the government, all information about the process.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation of Illinois Institute of Technology, 35 West 33rd Street, Chicago 16, Ill., has great need for the chemicals listed below. If anyone has one or more, even if only in one gram quantity, please inform the Registry.

2,4,6-Trimethylheptane
2,4,6-Trimethyloctane
3,5,7-Trimethylnonane
2,2,3-Trimethylbutene-3
Tetramethylammonium nitrate
1-Methylcyclohexanol
Perfluoro-n-heptane
Octadecenyl aldehyde
cis-l-Chloro-1-propene
trans-l-Chloro-l-propene
cis-Dibromoethylene
l-Methylcyclopentene
Trimethylhexaldehyde
Tri-n-amyl phosphate
Perfluoroisobutylene
N-Methycylclohexylamine nitrite
3-Keto-butanol-1
3,4-Lutidine
1-Ketoadipic acid
Ethyl n-amyl ether

Can Mileage Be Doubled?

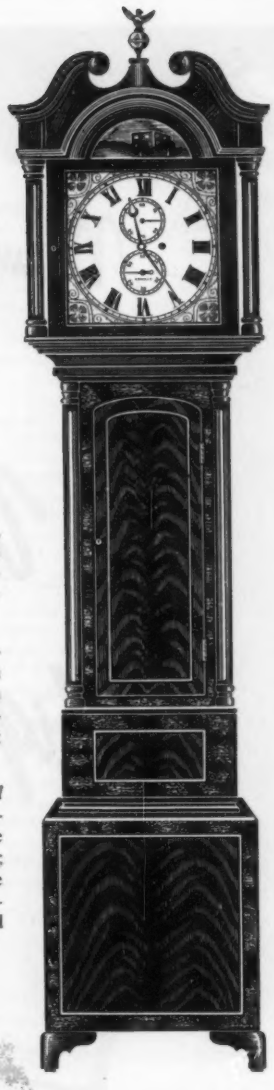
The current miles-per-gallon performance of automobiles of today can be doubled in the future to help offset the price increases arising from any growing scarcity of domestic oil.

These were the words of Dr. Donald Frey, director of engineering of Ford Motor Co., as he spoke before a University of Michigan audience. Dr. Frey said that the three developments that are possible are: (1) more efficient engine design, (2) smaller cars, and (3) engines that would use lower octane or no-octane fuels.

Seek Automation Ideas

Automation engineers in this country are again conducting an inventors' contest this year. New ideas in automation will be judged from all fields of instrumentation.

The second "New Ideas in Instrumen-

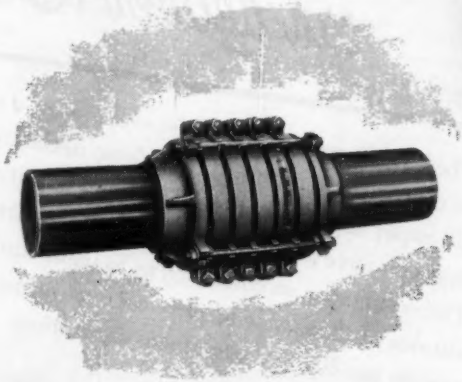


19,862 years of precision metal-forming

When you specify FLEXON® Expansion Joints, you actually *buy time*—19,862 years of combined experience in the team of engineers, metallurgists, and technicians who produce Flexon Expansion Joints!

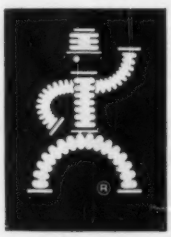
And all this time has been invested in perfecting formed and corrugated tubular shapes in metal, made with watch-like precision—flexible metal hose, instrument-type bellows, "impossible" bends and section modulations for aircraft parts . . . **and expansion joints of every kind.**

So—for expansion joints that you can *install and forget*—always specify FLEXON. Free-flexing and controlled-flexing; dual and multiple types; balanced joints and other special designs; all in stainless steel, monel, and other workable alloys. Assured longer service life, through careful analysis of your application plus unmatched skill in manufacture.



Write today for your copy of the Flexon Expansion Joint Design Guide—28 pages of facts about absorbing pipe motion.

EJ-210



Flexonics corporation

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EXPANSION JOINTS | METAL HOSE | NON-METALLIC HOSE | BELLOWS | AIRCRAFT COMPONENTS

GENERAL CABLE

CATHODIC PROTECTION CABLES

COPPER or ALUMINUM CONDUCTOR

AQUATHENE

AQUASEAL heat and moisture resistant rubber insulation with neoprene jacket overall for direct earth burial under normal soil conditions.

Special Advantages of AQUATHENE

Highly resistant to moisture, earth chemicals, heat and mechanical damage. Exceptionally pliable at normal and low temperatures.

GENCATHENE

Polyethylene insulation, **GENCASEAL** (PVC) jacket* for applications requiring not only moisture resistance but also protection against oil, gasoline and grease.

*For special applications such as exposure to chlorine gas, similar cables having high molecular weight black polyethylene uni-insulation and jacket to the same outside diameters are available.

Special Advantages of GENCATHENE

Excellent resistance to oils, acids, alkalis, grease, and chemicals in greater than normal concentrations.

ADVANTAGES COMMON TO BOTH TYPES

- Suitable for direct burial
- Easy to handle, splice and terminate
- Light in weight
- Low in cost
- Exceptional resistance to moisture and weather
- Excellent electrical stability
- High resistance to electric osmosis

GENERAL CABLE CORPORATION, 420 Lexington Avenue, New York 17, N. Y.

Offices and Distributing Centers Coast-to-Coast

for quality and economy... **specify GENERAL CABLE**

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening. . .

tation Contest" searching for outstanding technological advances in the broad field of automation will be conducted by the Instrument Society of America as a part of the 12th Instrument-Automation Conference and Exhibit to be held in Cleveland, September 9-13, 1957. Cash prizes will be awarded to winners but also important to contestants is the potential commercial development of outstanding ideas through the publicity. Deadline for entries is July Fifteenth (15th).

Entry blanks for the "New Ideas in Instrumentation Contest" may be obtained from S. D. Distelhorst, Director of Membership Relations, Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pa.

Fire Fighting Clinic Slated

Techniques for fighting oil field and refinery fires will be demonstrated at the second annual Southwestern Fire and Safety Clinic to be held in Tulsa, June 21, by the Walter Kidde Sales and Service division of Allan Edwards Manufacturing Co.

During the day-long session at the Edwards Safety Center, 2445 So. Jackson Ave., experts will give demonstrations of the proper methods, extinguishing agents and equipment for quelling oil and gas blazes.

About 100 persons attended last year's clinic and 500 have been invited to the coming event. All interested oil industry personnel are invited to attend and reservations may be made by contacting the Edwards Company at Box 7218, Tulsa. There is no charge.

Wage Hikes Taking Shape

With wage negotiations continuing all over the country, it begins to look more and more like the Oil Chemical and Atomic Workers union is set to settle for a six percent wage increase. This same figure is also gaining ground as a general industry trend being offered to all hourly wage and salaried employes.

The only stumbling blocks that appear are minor ones such as whether the increase will be retroactive to the first of April or May; and whether a four week vacation will be given after 20 to 25 years. On the whole, however, it appears as if union and management are very close together, and that the six percent increase will be the general pattern, providing these smaller differences can be ironed out.

Definite wage increases that have been settled so far include:

Tidewater Oil Co., six percent wage increase with four weeks vacation after 20 years of service for employes of eastern division. Increases retroactive to May 1.

Texaco's Port Arthur refinery—five percent hike retroactive to April 1, and another one percent effective May 1.

Esso Standard installations—at Everett Mass. refinery and Pittsburgh plant, six percent increase and four weeks vacation after 20 years.

Sun Oil Co.—six percent increase as of April 16, with four weeks vacation after 20 years, and added holiday. Small number of employes have not yet accepted.

Humble Oil & Refining—six percent hike, eight holidays, and four weeks vacation after 20 years to all non-represented employes. Same offer to union represented personnel.

Atlantic Refining Co.—six percent increase effectve April 22, to all union and salaried employes.

Royalite Oil Co., Ltd.—eight percent increase with three weeks vacation after ten years, and four weeks after 25 years.

Phillips Petroleum Co.—five percent hike retroactive to April 1, and four weeks vacation after 20 years of service, to all non-represented employes. Same offered to all union personnel.

Sunray Mid-Continent Oil Co.—five percent hike retroactive to April 1, and four weeks vacation after 20 years of service to all non-represented employes. Same offered to union personnel.

Shell Oil Co. and affiliates—six percent wage increase and four weeks vacation after 20 years of service to all employes.

Although the general six percent plus four weeks seems to agree with most OCAW locals, some independent unions belonging to the Federation of Independent Oil Unions have voted to stand firm in taking "no less" than six percent or 15 cents an hour for hourly workers, and six percent or $26 per month for salaried employes.

They will also take "no less" than double-time-and-a-half for holiday work, eight holidays, and four weeks vacation after 20 years of service, in "fringe" benefits.

Cost Engineers to Meet

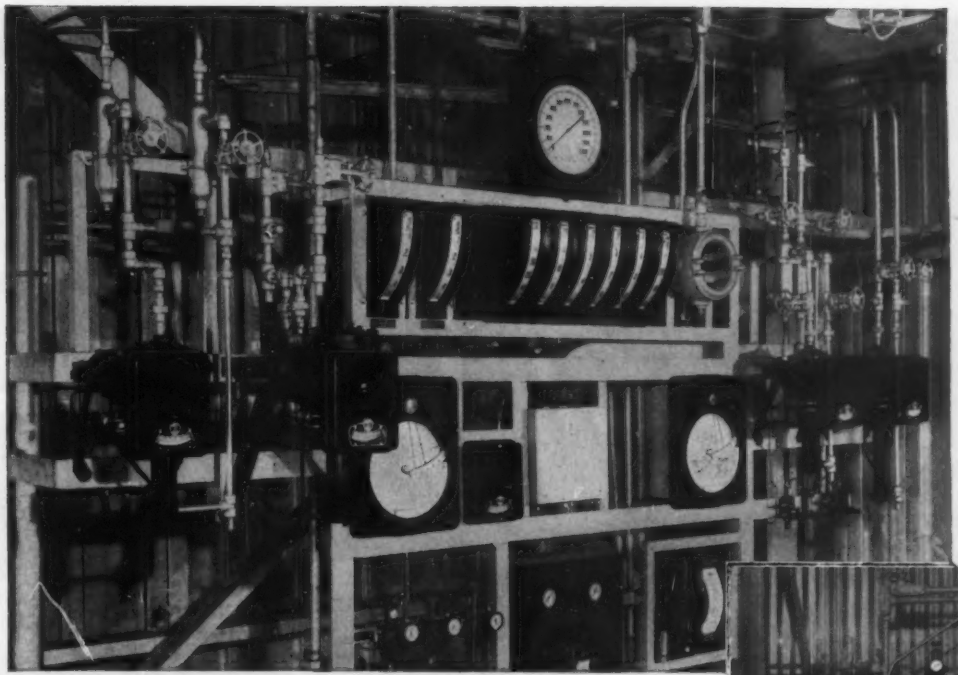
The American Association of Cost Engineers will hold its first annual meeting this month at the University of New Hampshire, Durham, N. H. The following program has been arranged:

WEDNESDAY, JUNE 26

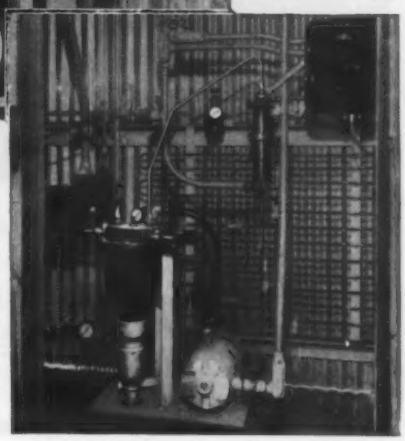
Morning

(Chairman—Professor O. T. Zimmerman, University of New Hampshire)

Registration



These Bailey Pneumatic Transmitters on CO boiler at Tidewater measure and transmit: Fuel gas flow, drum level, per cent oxygen, steam pressure, furnace temperature, CO gas flow, steam flow, duct and furnace pressures. Other Bailey transmitters (not shown) measure feed water flow, oil flow, air flow, and steam temperatures.



Bailey Gas Analyzer for oxygen and combustibles in flue gas.

Bailey Control for CO Boiler at Tidewater...

Bailey Instruments and Controls help Tidewater Oil Company to secure design performance from the new carbon monoxide boiler in its Delaware Refinery. The Bailey Equipment here is of the pneumatic transmission type operating on a standard 3-15 psi signal range. This allows a wide selection of receiving instruments for control room service.

Bailey Controls on the CO Boiler function to maintain:

1. Steam Pressure
2. Steam Temperature
3. Elevated Furnace Temperature for combustion of CO
4. Optimum fuel-air ratio for all mixtures of CO and supplementary fuels
5. Safe water level in boiler drum
6. Proper differential between pressures in boiler drum and at feed water pump outlet
7. Circulation through boiler feed pumps.

For combustion "know-how" with standardized instrument and control components, see your local Bailey Engineer or call our headquarters at Cleveland.

CP2-1

BAILEY BUILDING BLOCK METHOD

BAILEY METER COMPANY

CHEMICAL AND PETROLEUM DIVISION

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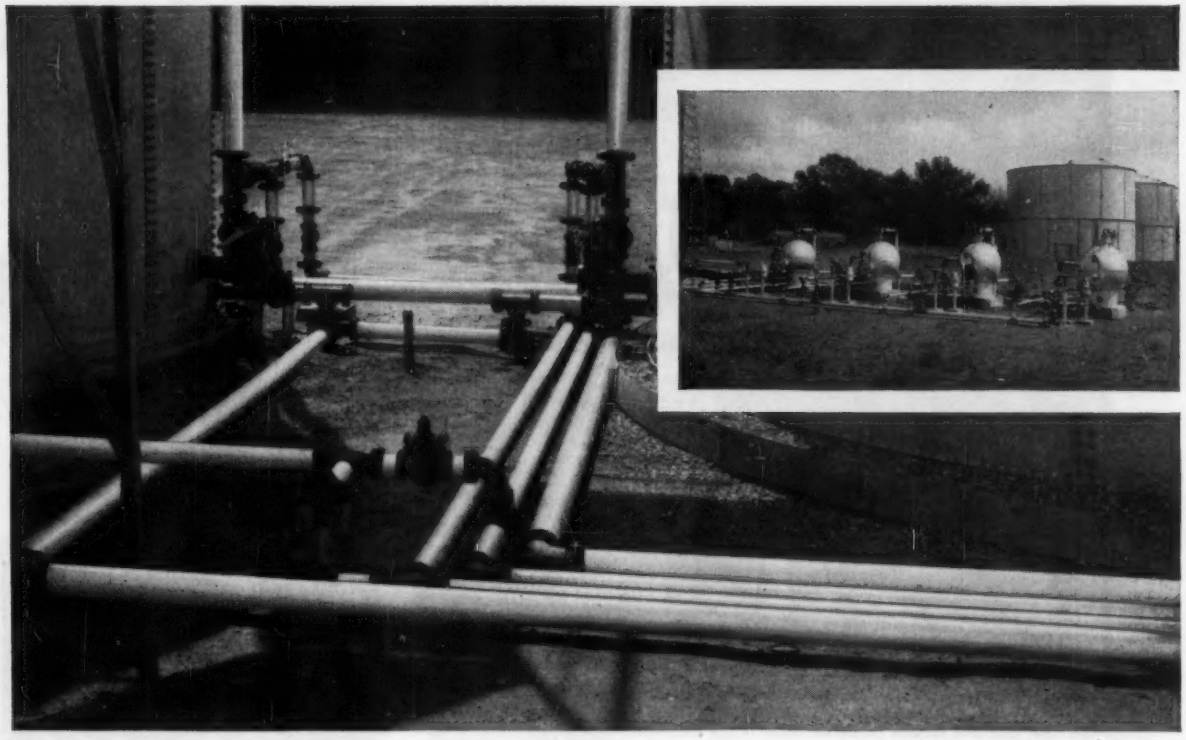
In Canada—Bailey Meter Company Limited, Montreal

RESULTS IN: FLEXIBILITY, SIMPLICITY, ECONOMY

BAILEY METER



Aluminum Pipe Saves $284 on 600 bbl. Tank Battery Hookup

If you have a two-tank, 600 barrel storage battery, you can save from 25% to 30% on hookup costs as one Victaulic Coupling user did. How? By using Reynolds Aluminum Oil Country Pipe instead of T & C black line schedule 5 pipe.

Not only was Reynolds Aluminum Oil Country Pipe less expensive than the equivalent black line pipe, but it was easier to cut, groove, couple and handle; it will never need painting. Labor costs to install the hookup were cut about 40%. And these savings hold for a wide range of piping jobs in the drilling, production, processing and transportation fields.

Lightweight Reynolds Oil Country Pipe cuts installation time and labor wherever it goes. One man can carry a 30 foot section easily; one truck can carry *three miles* of pipe! You can figure about 10 man-hours per mile for laying an aluminum line—compared with 50 or 60 man-hours for steel. And Reynolds Aluminum Oil Country Pipe is easy to hook up; it's flexible, so it can be contoured over rough ground, can make shorter turns.

Aluminum's resistance to rust and corrosion makes it even more practical in seawater, or in handling corrosive chemicals, crude oils and refined gases.

You'll find Reynolds Oil Country Pipe easy to get, too. It's stocked by leading suppliers throughout the oil country, and standard aluminum fittings are available from top manufacturers.

Get all the facts on how much you can save—in first cost, installation costs, and over-the-years maintenance and operating costs—with Reynolds Aluminum Oil Country Pipe. Phone your local Reynolds office (listed under "Aluminum") today.

Write for free brochure:
Reynolds Aluminum Pipe for Tank and Battery Hookup, Reynolds Metals Company, P. O. Box 1800-C T, Louisville 1, Kentucky

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

See "CIRCUS BOY", Reynolds exciting dramatic series, Sundays on NBC-TV.

For more data on advertised products, use Readers' Service Cards, last page.

"Industry's Capital Spending Plans"
(By McGraw-Hill Economics Department Representative)
Cost Index and Cost Trends Session
(Moderated by O. T. Zimmerman)

Afternoon

(Chairman—T. C. Ponder, Petroleum Refiner)
"Depreciation Effects on Payout Time in Project Desirability Appraisal" (Dr. B. J. Gaffney of Rust Engineering Co.)
Discussion
(E. H. Flewellen, Celanese Corp., N. Y. and from the floor)
"Up-to-Date Costs of Tanks, Vessels and Heat Exchangers"
(W. J. Hagerty of Colonial Iron Works)
Discussion
(R. Huttenlocher, National Carbon Co., and from the floor)

Evening

Semi-Formal Dinner
AACE Award of Merit for 1957 to an Outstanding Cost Engineer.

THURSDAY, JUNE 27

Morning

(Chairman—S. Katell, U. S. Bureau of Mines)
"Cost of Construction and Operation of Interstate Natural Gas Pipelines" (C. T. Kallina, Federal Power Commission)
Discussion from the floor
"Cost Determination of Gas Supply for Peak Shaving and Substitute for Natural" (M. P. Griffith, NEGEA Service Corporation)
Discussion from the floor
"Manufacturing Cost Estimating"
(R. H. Hill, Monsanto Chemical Company)
Discussion by R. S. Aries of R. S. Aries and Associates and from the Floor
Lunch
"Some Estimating Experiences"
(Dana Peaslee, retired, Chief Estimator for Badger Company for 28 years)

Afternoon

"Process Piping Cost Estimating"
(W. G. Clark, Dow Chemical Company)
Discussion
"Comparison of Capital and Operating Costs for Different Processes Making the Same Product"
(W. C. Schroeder, University of Maryland)
Discussion

Evening

Clam Bake

FRIDAY, JUNE 28

Morning

(Chairman—N. G. Bach, Monsanto Chemical Company)
Business Meeting
Report of Admissions Committee
Report of Publications Committee
Report of Regional Study Committee and of Local Sections
"A Blueprint for the future of A.A.C.E."
(D. F. Brosnan, Foster-Wheeler Corporation)
Balloting for Meeting Location.
Lunch
Announcement of Next Meeting Location, etc., (N. G. Bach)

Afternoon

(Chairman—J. T. Husted, American Potash and Chemical Corp.)
"A Review of Current Cost Publications"
(J. B. Weaver, Atlas Powder Company)
"An Estimating Standards Program for the A.A.C.E."
(C. A. Miller, Canadian Industries Ltd. assisted by Standards Committee Chairman. Coffee Break after Outline of Program by C. A. Miller)
"Recapitulation"
(O. T. Zimmerman)

OCAW Voted Down

The hourly wage earners at Esso's Bayway refinery have delt a rebuff to the Oil, Chemical, and Atomic Workers Union, by voting to affiliate with a new independent union rather than the powerful OCAW headed by O. A. Knight.

In an election supervised by the National Labor Relations Board, the vote was 1123 for the Independent Petroleum Workers Union of Bayway, and 825 for OCAW.

The result was also a repudiation of the leadership of the present independent union, the Independent Petroleum Workers of New Jersey. The IPWNJ which had been plugging for affiliation with OCAW, is now left representing only salaried employes.

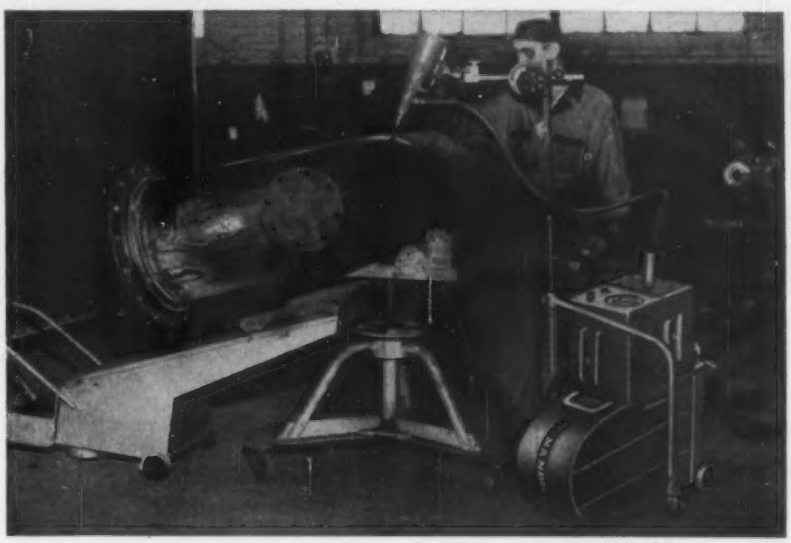
What's Happening . . .

—Awards—

The Reserve Award of the U. S. Department of Defense was presented to the Richfield Oil Corp. in San Francisco for outstanding cooperation with the Armed Forces vital reserve program.

In a brief, public ceremony at the Presidio of San Francisco, Lt. Gen. Robert N. Young, commanding general of the Sixth Army, presented the award and its accompanying citation and pennant to Charles S. Jones, Richfield president.

Authorized and signed by Defense Sec-



SPEED AND X-RAY QUALITY WELDS FOR FLANGES AND FITTINGS WITH A "SQUIRT" WELDER

Greater speed and X-ray quality are simple to achieve with the Manual Lincolnweld "Squirt"—a semi-automatic, submerged arc welder. Lincolnweld offers:

- **Higher currents** for deep penetration and speed.
- **Accurate control** to assure the best weld possible.
- **Versatility** for easy change-over from one job to the next.
- **Low cost.** Lincoln "Squirt" unit costs less than $310 anywhere in the country. Operates from standard Lincoln 600 amp. motor-generator, 500 amp. rectifier, or 600 amp. engine welders.

Other factors, such as more operator comfort, self-cleaning welds and ease of use without expensive fixtures, make additional contributions to lower welding costs.

FABRICATORS!
You can learn all the facts about "Manual Lincolnweld" in Bulletin SB-1303. Write for it!

THE LINCOLN ELECTRIC COMPANY
Dept. 2209 • Cleveland 17, Ohio
The World's Largest Manufacturer of Arc Welding Equipment

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

retary Charles E. Wilson, the award was given Richfield for aiding and encouraging its employes to participate in reserve activities and training; helping to design and equip a mobile petroleum products laboratory for the 968th Quartermaster Corps, which has been widely adopted by other U. S. military units; and the public service television show, "Success Story," which presented a dramatic story of the 91st Infantry Division and the reserve program.

Shell Oil Co. has received the Department of Defense Reserve Award for "outstanding cooperation" to the Reservists and Reserve activities. The award, consisting of a pennant and a certificate of citation, was made during ceremonies held at the Waldorf Astoria.

In making the award, Admiral Miles said Shell has frequently given assistance and advice to the Armed Forces in Petroleum Research. He also pointed out that Shell makes company facilities available for Naval Reserve use.

Shell employees who have completed one or more years of service with the company are paid the difference between their normal earnings with the company and their military pay during leaves of absence for military service up to fifteen days in a calender year. Such leaves are in addition to the employees' regular vacation.

– Changing Times –

First state to enact air pollution law in 1957 is New York. Law creates a board that will set the standards, then in 1959 board will receive power to enforce them. **Board will have power to levy fines of up to $500 for offenses,** and $100 a day for as long as the offense continues. It will also be able to get injunctions to halt persistent offenders.

OIC will continue program of building long-range good will rather than zeroing-in on spot public relations problems.

What do employes want in a company magazine? Recent survey by Sunray Mid-Continent revealed **they dislike most** of all articles about people and hobbies. Editorials and news briefs ranked second and third in disfavor. **Order of favorites were** articles on company operations, on company policy, and on company benefits.

Institute of Chemical Engineers in U.K. will receive royal charter. This will reportedly confirm status of the profession in Great Britain and increase its attractiveness.

Three California refiners have received approval to purchase crude oil from Navy's Elk Hills Petroleum Reserve. Contracts, covering three-year period, involved purchases of 16,000 bpd, and were awarded to **Rothschild Oil, Mohawk Petroleum, and Douglas Oil.**

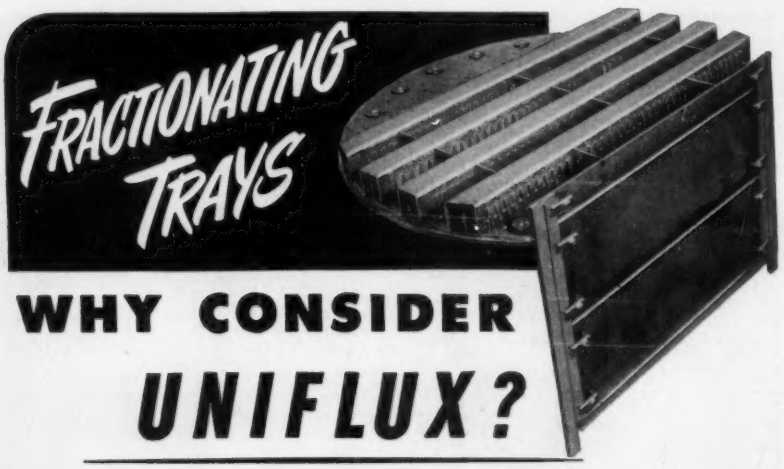
OEEC has estimated **Western Europe's total demand for refined products will rise to 157 million tons in 1962.** This figures as a 52 percent increase over 1955.

Name changes in the news—**National Distillers Products Corp. became National Distillers and Chemical Corp.** Another: **Union Carbide and Carbon Corp. shortened to Union Carbide Corp.** Company divisions followed along also as Carbide and Carbon Chemicals Co. became Union Carbide Chemicals Co.; and Linde Air Products Co. shrunk to Linde Co.

F. L. Martin, president of Suntide Refining Co. has confirmed widespread rumors that **negotiations are in progress for the purchase of his company by Southern Natural Gas Co.** No further details are available.

Recent bid of International Contractors and Suppliers Assn. to build Argentina's oil facilities **was no small package.** It weighed 65 pounds.

Tidewater Oil Co. will stick to **two grades of gasoline . . . Shell Oil will supply the turbine fuel** for first U. S. long-range turboprop transport . . . efforts are being made to line up **300 mayors to fight the gas bill again . . .**



WHY CONSIDER
UNIFLUX?

FOR LOWER COST? . . . . . YES!
(25% to 50% Lower)

FOR COMPARABLE CAPACITY? . . . . YES!
(Equal or Better Than Conventional Designs)

FOR HIGHER EFFICIENCY? . . . . . YES!
(Closer Approach to Equilibrium)

FOR MAXIMUM FLEXIBILITY? . . . . YES!
(Wide Operating Range)

FOR MINIMUM MAINTENANCE? . . . YES!
(Simplified Installation, Self-Cleaning Characteristics)

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SPECIFIC APPLICATIONS

MISCO FABRICATORS, INC.
Designers, Builders, Fabricators of Heat Resisting Alloy and Stainless Steel Equipment

2420 WILLS AVENUE • MARYSVILLE, MICHIGAN
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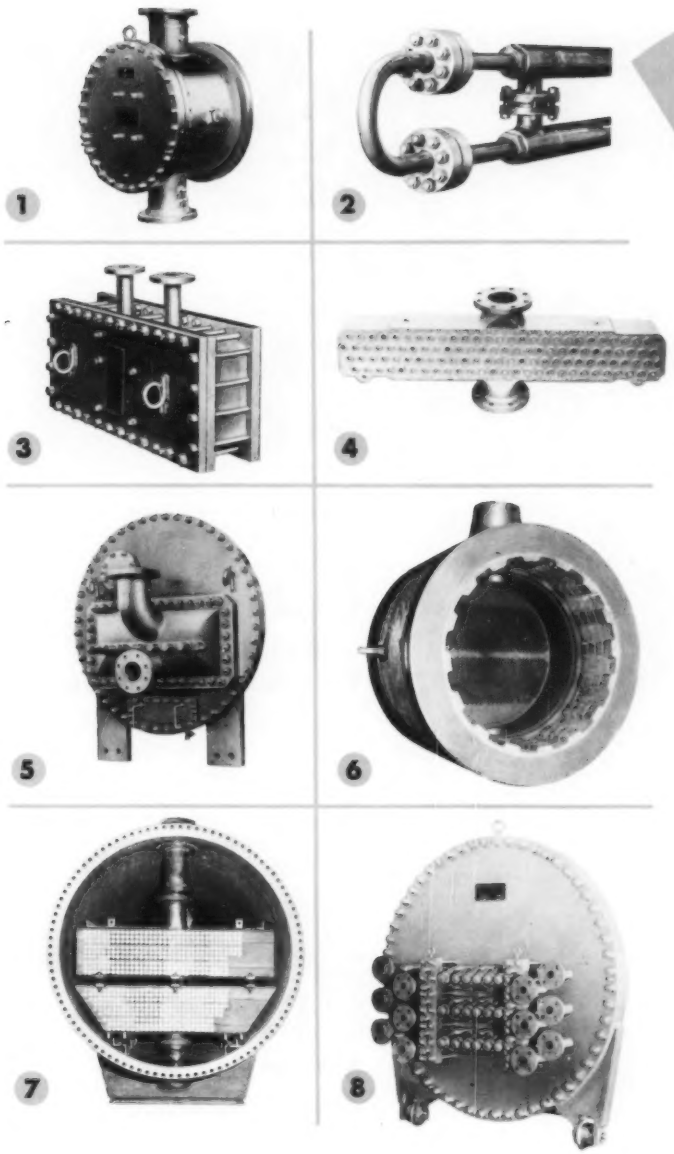
For more data on advertised products, use Readers' Service Cards, last page.



How many of these heads do you recognize ?

...they all belong to G-R heat transfer units

These are the heads of some of the many different types of heat transfer apparatus available from G-R. They indicate the wide range of G-R units . . . for condensing, cooling, heating or heat exchange . . . for any liquid, vapor or gas . . . for any capacity, pressure and temperature.

G-R designs and recommendations are backed by 90 years of G-R experience, the results of G-R continuous research and product improvement, and the performance records of many thousands of G-R installations throughout industry and all over the world.

Get the benefit of these assurances of authoritative advice and successful service for your particular heat transfer requirements. There's a helpful G-R representative near you. Write us about your needs and he will promptly get in touch with you.

1. Tubular Heat Exchanger, for a great variety of services in transferring heat from one fluid to another

2. Twin G-Fin Section, a unit with a wider range of heat transfer services than any other design on the market

3. Air and Gas Cooler, for cooling the air or hydrogen from generator windings and for other gas cooling or heating services

4. Atmospheric Open Section, with Bentube or K-Fin elements for cooling or condensing services

5. Type R Evaporator, for producing distilled boiler feed make-up at moderate pressures

6. Type L Feedwater Heater, for the highest pressures encountered in central power generating stations

7. Type J-2 Evaporator, for producing large quantities of boiler feed make-up at high pressure

8. Steam Generator, using waste heat to produce steam at boiler pressure

THE GRISCOM-RUSSELL CO.

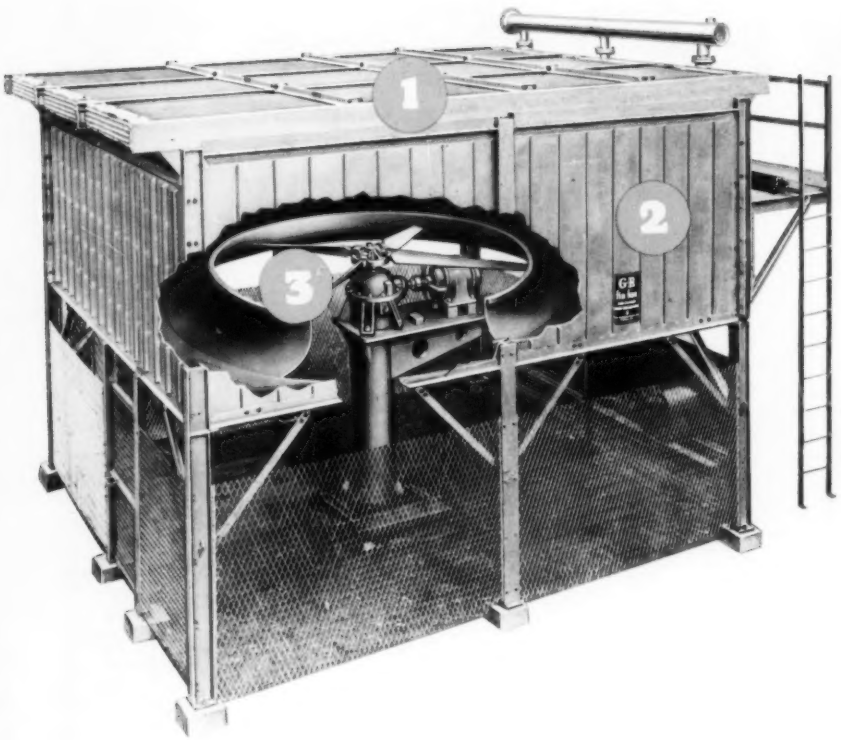
A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

MASSILLON, OHIO

GR 368

fin-fan

the Sturdy air-cooled heat exchanger



1

Sturdy K-Fin Cooling Sections

Designed for the highest pressures and temperatures encountered in cooling and condensing services, and for corrosive fluids—even hot liquid metal. Installations are operating at pressures up to 5,000 psi and temperatures up to 1,200 F.

2

Sturdy Structure

Built to withstand a wind load of 40 lb per sq ft, equivalent to a wind velocity of 100 mph; and can be designed to withstand earthquakes.

3

Sturdy Drive Mechanism

Driving units and speed reducers are specially designed for heavy-duty continuous operation, and are mounted on a sturdy pedestal with its own foundation, independent of the structure, for elimination of vibration.

You can confidently use G-R **fin-fan** for severe service conditions such as are often met in petrochemical plants and petroleum refineries. In addition to the exceptional sturdiness of every part of the unit, the design includes provisions for close temperature control and air-flow control, complete protection of operators and equipment, and wide selection of arrangements to suit plant conditions and operating requirements.

Write for complete information.

THE GRISCOM-RUSSELL CO.

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

MASSILLON, OHIO

GR372

MEETINGS CALENDAR

JUNE	
16–21	American Society for Testing Materials, Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N.J.
18–19	Rocky Mountain Oil and Gas Association, Annual Meeting of Refining Committee, Northern Hotel, Billings, Mont.
19–21	Twelfth Annual Meeting for Association for Computing Machinery, University of Houston.
20–21	Western Petroleum Refiners Meeting, Mid-Continent Regional Technical-Industrial Relations Meeting, Broadview Hotel, Wichita, Kan.
24–28	American Institute of Electrical Engineers, 1957 Fall General Meeting, Sheraton-Mt. Royal Hotel, Montreal, Canada.
26–29	American Association of Cost Engineers, First Annual Meeting, University of New Hampshire, Durham, N.H.
JULY	
8–19	Short Course in Industrial Statistics for Process Industries, University of Oklahoma, Norman.
8–26	Summer Session on Natural Gas Technology, includes Natural Gas Transmission, and Natural Gas Fuel Utilization, Institute of Gas Technology, Chicago.
AUG.	
7– 9	Sixth Annual Conference on Industrial Applications of X-Ray Analysis, Metallurgy Division, Denver Research Institute. University of Denver.
11–15	American Society of Mechanical Engineers, Heat Transfer Conference, Pennsylvania State College, University Park, Pa.
19–21	Cryogenis Engineering Conference, host will be National Bureau of Standards in Boulder, Boulder, Colo.
28–30	Analysis Instrument Committee's International Symposium on Gas Chromatography, Kellogg Center, East Lansing, Mich.
SEPT.	
5– 6	API Oil Information Committee, Meeting, Broadmoor Hotel, Colorado Springs.
8–13	American Chemical Society, 132nd National Meeting, New York City.
9–11	American Institute of Electrical Engineers, Petroleum Industry Conference, Sheraton Hotel, Philadelphia.
9–13	Instrument Society of America, 12th Annual Inatrument Automation Conference and Exhibit, Cleveland Auditorium, Cleveland.
11–13	National Petroleum Association, 55th Annual Meeting, Traymore Hotel, Atlantic City, N.J.
15–18	American Institute of Chemical Engineers, Lord Baltimore Hotel, Baltimore.
22–25	The 12th Annual Petroleum Mechanical Engineering Conference, Mayo Hotel, Tulsa.
23–25	American Society of Mechanical Engineers, Fall Meeting, Statler Hotel, Hartford, Conn.
26–27	Western Petroleum Refiners Association, Rocky Mountain Regional Technical-Industrial Relations Meeting, Henning Hotel, Casper, Wyoming.
27	Natural Gasoline Association of America, Oklahoma Regional Meeting, Skirvin Hotel, Oklahoma City.
30–Oct. 2	American Oil Chemists' Society, 1957 Fall Meeting, Netherland Plaza Hotel, Cincinnati.
OCT.	
1– 4	National Association of Corrosion Engineers, North Central Region in Sherman Hotel, Chicago; South Central Region in City Auditorium, Oklahoma City.
5– 8	National Association of Corrosion Engineers, Northeast Region, Hotel Somerset, Boston.
7– 9	ASLE-ASME Lubrication Conference, Chateau Frontenac, Quebec, Canada.
7–11	American Institute of Electrical Engineers, 1957 Fall General Meeting, Morrison Hotel, Chicago.
9–11	Fourth Annual Symposium of High Vacuum Technology, Hotel Somerset, Boston.
10–11	California Natural Gasoline Associaition, 32nd Annual Fall Meeting, Huntington-Sheraton Hotel, Pasadena, California.
10–12	ASME, Fuels-AIME Conference, Chateau Frontenac, Quebec City. Que.

Photographer Bernard Hoffman found even the free flow of CO_2 from a cake of dry ice is difficult to control.

Controlling Flow in Fluid Engineering

To tame and control flow accurately, you must relate it to pressure, volume, turbulence and other variables. That's when you can look to the engineering leadership of S. Morgan Smith.

Butterfly valves are a good example. For the majority of processing situations, a wide range of standard R-S Butterfly Valves are assembled from stock for fast shipment. But for special fluid control problems, one or more can be applied to solve your needs. Standard or special, all R-S Butterfly Valves give you uniform flow control through all positions in the normal regulating range. You get minimum turbulence and pressure drop, save on pumping power because of simplified design and streamlined vanes. Compact and light in weight, they give you quick regulation and tight closure.

To learn more about the complete SMS line of Rotovalves, Ball and Butterfly Valves, call on our nearest representative. For information on special engineering, write S. Morgan Smith Co., York, Pa.

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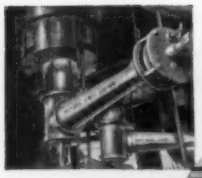
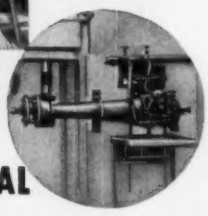


VERTICAL



OR

HORIZONTAL

many more hours on stream without forced shutdown with NATIONAL AIROIL

OIL-GAS TANDEM COMBUSTION UNITS

Exclusively for vertical firing, the new National Airoil VERTICAL Tandem Block Units retain all the features of our regular horizontal Tandem Units . . . plus: special, precast refractory shapes for easier, cost-saving vertical installation and maintenance; secondary air inlet louvres for positive control of vertical flame pattern; and, all steel duplex detaching gear which enables swift, simple vertical burner change-over.

VERTICAL and HORIZONTAL Tandem Units hold air in the combustion zone until fuel and heated air are thoroughly mixed. This means that ignition takes place in a hot zone; the result: high fuel economy through more rapid combustion with a minimum of excess air. NATIONAL AIROIL's patented Tandem Combustion Units allow secondary air to be easily and accurately controlled. By adjusting air control louvres, flame can be shaped to radiate heat uniformly without tube impingement.

The VERTICAL or HORIZONTAL Tandem Unit is always fired with NATIONAL AIROIL Combination Oil and Gas Burners . . . has a high turndown ratio with a steady flame temperature using either fuel oil or gas. With the TANDEM UNIT's clean flame, a cold furnace can be brought to full capacity in a short time.

"Many, many more hours on stream, without shutdown" . . . yes, YOU will realize higher profits from YOUR heaters when NATIONAL AIROIL VERTICAL or HORIZONTAL Tandem Units are specified. Our new Bulletin 498 is yours for the asking.

CHEMICAL-PETROLEUM DIVISION

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2512 South Boulevard, Houston 6, Texas
INDUSTRIAL OIL BURNERS, GAS BURNERS, AND FURNACE EQUIPMENT

Reviewing New Books . . .

"Project Engineering of Process Plants"

Written by **Howard F. Rase** and **M. H. Barrow**, this is the first book to recognize the new Profession and to formalize the methods of executing a project used by all progressive chemical companies and engineering firms. It is also the first work devoted to process plant design which is written in accordance with modern techniques of project organization, planning, and execution.

The authors approach the subject from the point of view of the project engineer—the specialist whose profession demands organization and technical know-how in all phases of engineering. It is his job to coordinate and supervise the design and construction of a modern plant.

The book is not limited solely to the project engineer, however. Any engineer whose work requires a knowledge of the theories and techniques of mechanical design, procurement, and construction will find it invaluable.

To facilitate easy understanding, the book includes a wealth of excellent illustrations of equipment and examples of actual design calculations, specifications, and contracts. References to information recorded in handbooks and codes, plus all other sources of information are given.

(John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 692 pages, $14.25. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

"Chemical Engineering Reports" How to Search the Literature and Prepare a Report

The author Kenneth Kobe has given a course in report writing to chemical engineering students at the University of Texas for a number of years. His text, after several revisions, is now published in book form.

Since the first thing to do in any engineering problem is "search the literature," the reports begin with a survey of chemical engineering literature, from general reference sources through journals, to patents and manufacturers' publications, and tells the reader how to make a literature search.

Mr. Wood B. Engineer is told how to prepare a report. He is given some principles of effective writing, largely in the form of a reprint, in an appendix, of Dr. H. J. Tichy's excellent series of articles, "Engineers Can Write Better." He is given examples of the organization of various kinds of reports, including a very clear and helpful section on how to write a business letter. An excellent section tells how to manipulate a typewriter to produce mathematical symbols, Greek letters, chemical formulas, etc., and there is useful information on mimeograph, duplicator and other reproduction processes. The usefulness of these sections is not confined to the young engineer who has to do his own typing, and many secretaries will be able to profit from the clear account of how to present literature citations.

(Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 175 pages, $3.00. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

"Mathematics and Computers"

Written by George R. Stibitz and Jules A. Larrivee, this book supplies a better idea of the relationships between pure and applied mathematics and the growing use of automatic computers.

Computing devices and their components are described, especially the automatic digital computer, the way it works and its capabilities and limitations. Non-digital computing devices also are covered. A treatment of the use of randomness in computation, and typical applications of computing devices in technology and business are covered.

This book surveys the work of the applied mathematician, the problems he studies, the methods he uses, especially computation methods, and the computing devices that help him in the application of mathematics to problems in science, engineering and business.

(McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y., 228 pages, $5.00. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

"Pump Selection and Application"

Written by Tyler G. Hicks, this book is a guide to help engineers—in all fields using pumps—to get more economy and efficiency from their installations.

Recognizing that the biggest problem facing many engineers today is how to select and apply the best pump for a given set of conditions, the author supplies step-by-step procedures for analyzing a pumping problem, finding the most suitable commercial pump for the job, and applying this pump to the conditions encountered. Over 400 illustrations add to the description of a wide range of problems and pump types.

(McGraw-Hill Book Co., 330 West 42nd St., New York 36, N. Y., 422 pages, $8.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

"Thermodynamic Properties of the Elements" Advance in Chemistry Series Number 18

This is a systematic presentation of thermodynamic data. Tabulated values of the heat capacity, heat content, entrophy, and free energy function of the solid, liquid, and gas state of the first 92 elements are given for the temperature range of 298° to 3000° K. Auxiliary data include temperatures and heats of transition, melting and vaporization and vapor pressures. Literature sources are listed. The published values have been analyzed and are supplemented by estimates when experimental data are lacking. With the aim of providing the basic data for the elements needed in the calculation of the thermodynamic properties of chemical compounds, the tables were compiled by D. R. Stull and D. C. Sinke at the Thermal Laboratory of Dow Chemical Co. These up-to-date tables especially fill the need for data in the increasingly important high temperature region.

(American Chemical Society, Special Publications Department, 1155 Sixteenth St. N.W., Washington 6, D. C., 234 pages, $5.00.)

Remarkable resistance to heat and harsh chemicals

PROPERTIES OF "ARMALON" FELTS

GENERAL

Highly resistant to strong acids and bases at all temperatures.

Unaffected by water, common fuels, lubricants, hydraulic fluids, solvents.

High anti-stick properties.

Low coefficient of friction.

For FILTERING MATERIALS—tetrafluoroethylene felts

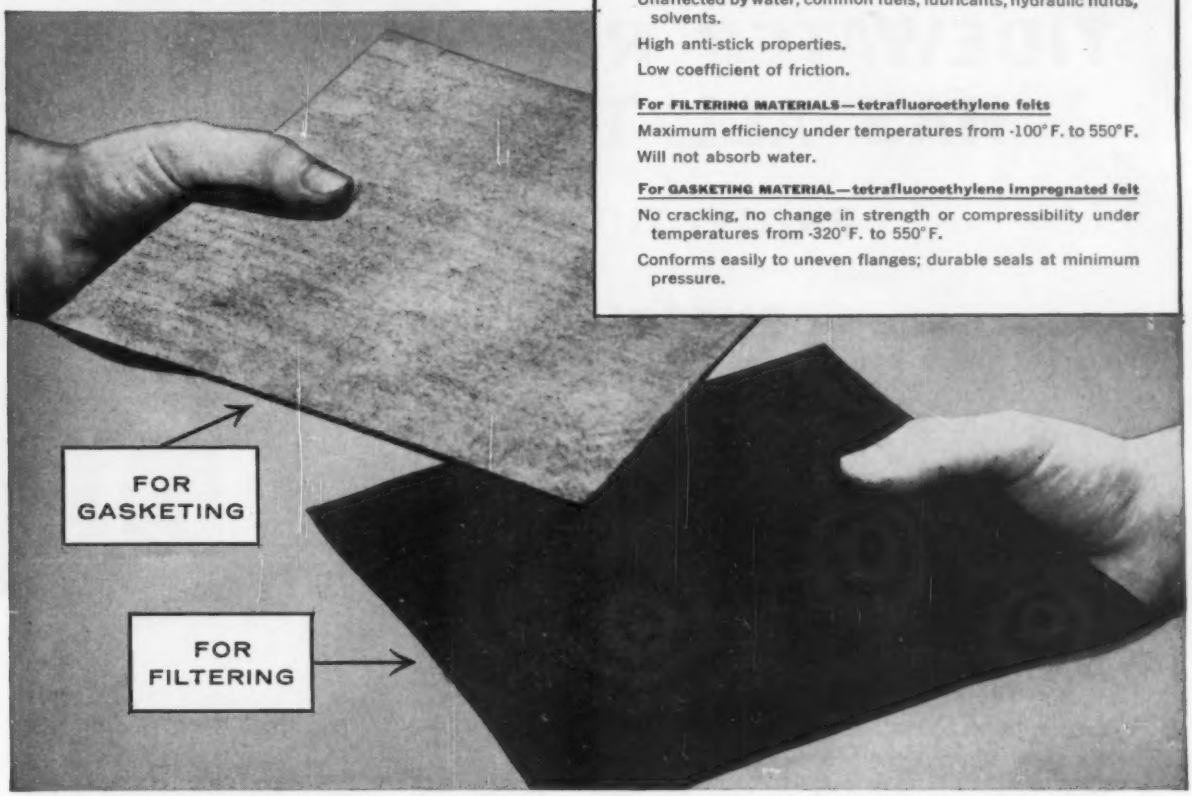
Maximum efficiency under temperatures from -100° F. to 550° F.

Will not absorb water.

For GASKETING MATERIAL—tetrafluoroethylene impregnated felt

No cracking, no change in strength or compressibility under temperatures from -320° F. to 550° F.

Conforms easily to uneven flanges; durable seals at minimum pressure.



New ARMALON® felts show exceptional service life in strong corrosives, temperatures up to 550° F.

Corrosion-resistant filters and gaskets of new "Armalon"* tetrafluoroethylene resin assure extraordinary long life felts where other materials fail entirely. They've proved their superiority in systems handling strong acids and bases—at temperatures from -320°F. to 550°F.

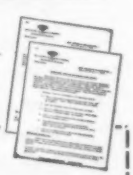
"Armalon" is the new felted form of Du Pont's "Teflon"** tetrafluoroethylene resin, available in two constructions—one for filtering, the other impregnated for gasketing†. "Armalon" is inert to water, common fuels, lubricants, hydraulic fluids, solvents and corrosive chemicals.

FILTERS of "Armalon" remove fine particles at high flow rates with minimum pressure drop. Anti-stick property of "Armalon" means longer service life, easier cleaning.

GASKETS of "Armalon" seal securely and last months, even years, longer than other materials. Advantages include substantial reductions in costly replacement shutdowns.

For more facts that may help you find a place for "Armalon" felts in your operations, fill out and mail the coupon. You'll receive Du Pont's free descriptive bulletin, including specifications.

*"Armalon" is Du Pont's registered trademark for its tetrafluoroethylene felts and impregnated felts.
**"Teflon" is Du Pont's registered trademark for its tetrafluoroethylene fiber.
†"Armalon" tetrafluoroethylene impregnated felt is covered by U. S. Patent 2,764,506.



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E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division, Dept. PR76
Wilmington 98, Delaware

Please send me descriptive bulletin on "Armalon" felts.

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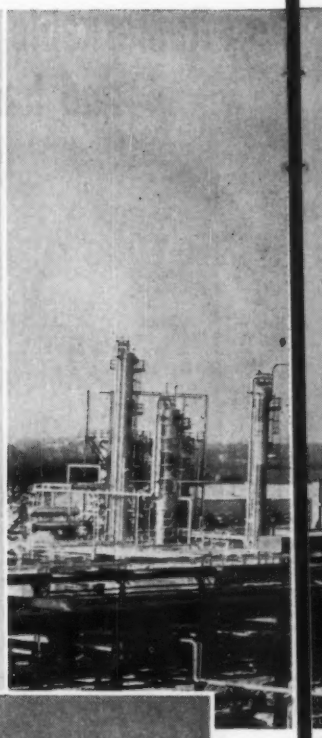
GIANT TIDEWATER REFINERY HAS ALL THREE

PROTECTION

CONTROL

MEASUREMENT

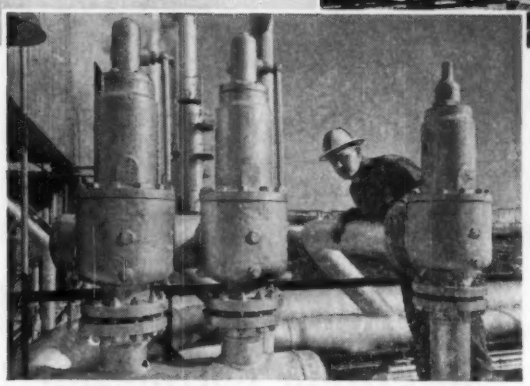
with reliable products of Manning, Maxwell & Moore



The Tidewater Oil Company's mammoth new Delaware Refinery is rightly referred to as the "refinery of the future." C. F. Braun & Co., engineering contractors, built the plant on the 5,000 acre site. Most of the processing units are unequalled anywhere for size and capacity. Tidewater incorporated the most advanced design and equipment to assure the greatest flexibility, economy and safety.

To provide around-the-clock protection, control and measurement, this ultra-modern refinery makes full use of dependable Consolidated Safety Relief Valves, Hancock Valves and Ashcroft Pressure Gauges. These products of Manning, Maxwell & Moore are precision engineered and built to insure the perfect performance, freedom from costly maintenance and long-life service so vital to economical refinery operations.

Whether you are modernizing or enlarging your plant for increased capacity . . . whether you are scheduling a "turn-around," planning a new processing unit or adding storage facilities – call on Manning, Maxwell & Moore regarding problems in protection, control and measurement. District offices and industrial distributors in the United States and Canada as well as agents and manufacturing licensees throughout the world are ready to serve you.



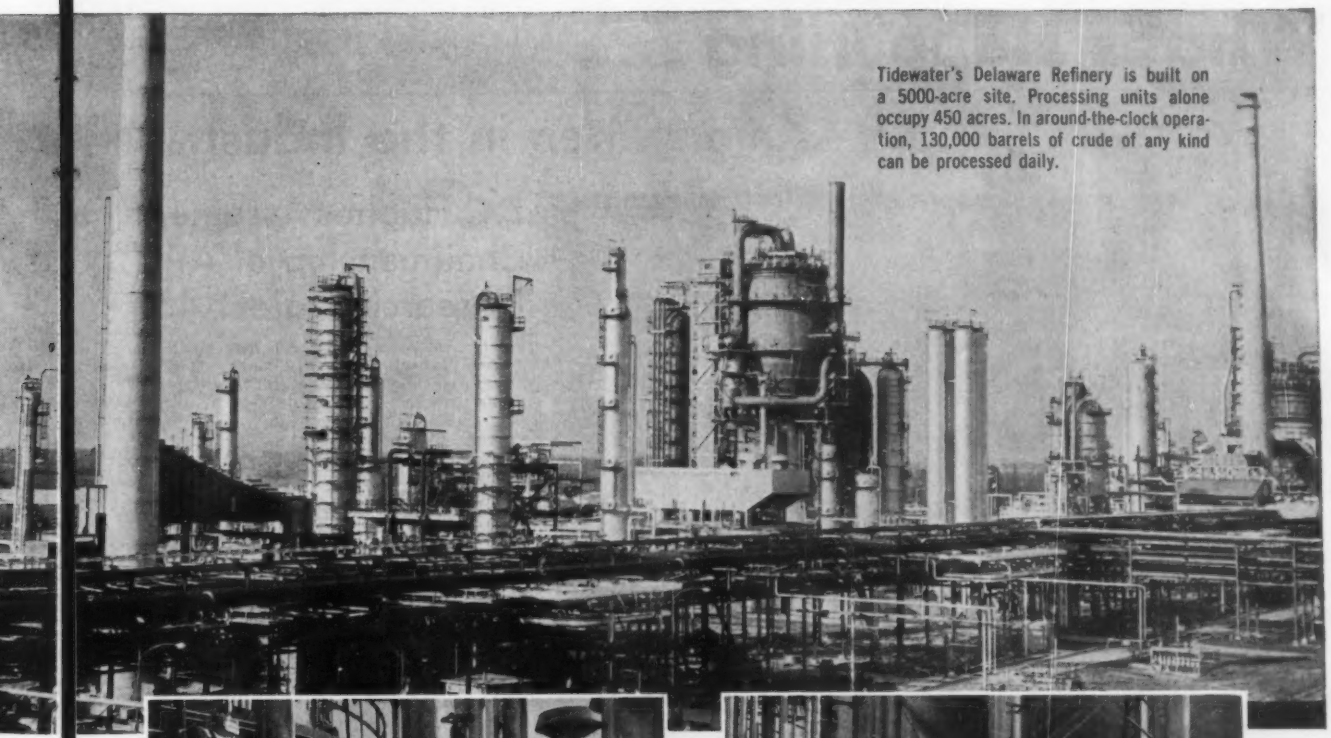
PROTECTION

. . . by CONSOLIDATED SAFETY RELIEF VALVES. The Orthoflow fluid catalytic cracker at Tidewater's Delaware Refinery is the world's largest. It is equipped with Consolidated Safety Relief Valves as are the propane storage bullets. These valves assure absolute protection through peak performance and consistently positive action, even where "superimposed" back pressure is in the relieving system.

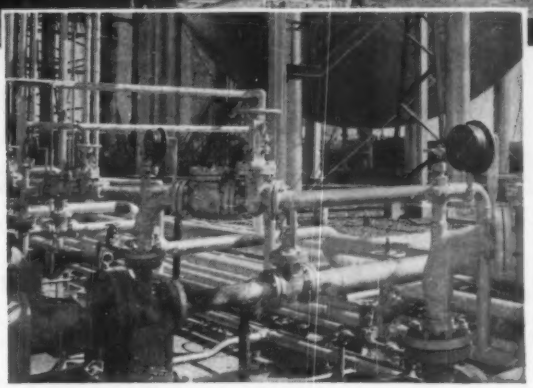
Consolidated Safety Relief Valves are "2 in 1" valves with interchangeability so highly perfected that the Standard valve can be converted to the Balanced Bellows Seal type *in the field*. Standardized inlet and outlet face-to-face dimensions permit these valves to be interchanged with those of some other manufacturers.

Fewer functional parts and precision machining and alignment of parts assure long valve life and less maintenance.

MANNING,



Tidewater's Delaware Refinery is built on a 5000-acre site. Processing units alone occupy 450 acres. In around-the-clock operation, 130,000 barrels of crude of any kind can be processed daily.



CONTROL

. . . by HANCOCK VALVES. The fluid-handling systems in Tidewater's Delaware Refinery must be kept at highest operating efficiency. To help control flow in the vast network of "fluid highways," hundreds of Hancock Valves are installed.

These manually-controlled valves are designed and built to give reliable performance under the pressures, temperatures and piping strains common to the most modern processing plant. All materials used in their construction are carefully selected — rugged strength and durability are engineered into every component. The super-hard seating surfaces are highly resistant to galling, steam cutting, wire drawing, erosion and corrosion. Positive tightness — leak-proof tightness — is assured month after month. Maintenance requirements are reduced to a minimum. Long-life service proves that there is no substitute for the economy of quality found in all Hancock Valves.

MEASUREMENT

. . . by ASHCROFT PRESSURE GAUGES. Accurate pressure measurement is essential to maintain product quality . . . to assure capacity performance of equipment and economical production in Tidewater's Delaware Refinery. Ashcroft Duragauges are precision instruments. They employ rotary geared motion — the most efficient and perfect method of transmitting mechanical motion. A choice of stainless steel movement or stainless steel with nylon bearings and pinion gear permits selection to meet specific requirements. Eight different Bourdon tube materials are available. Each Bourdon tube is "whip tested" at pulsating pressures approximately 50% higher than its pressure rating to insure calibration stability. Three case designs and materials and a complete range of dial sizes and pressures also provide for every individual need. Highest sustained accuracy and long service life are assured.

MAXWELL & MOORE, INC.

CONSOLIDATED ASHCROFT HANCOCK DIVISION

STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.*, 'HANCOCK' VALVES, *Watertown, Mass.*, 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Okla.*, AIRCRAFT CONTROL PRODUCTS, *Danbury, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.* **In Canada:** Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario.

MAXWELL MANNING M&M MOORE INC. TRADE MARK

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

. . . *Among Men* in the Industry

John Newton Mrs. Newton William Naden

John Newton Honored by API Refiners

In a surprise ceremony that clearly reflected the high esteem of his friends and colleagues, a beautiful silver tray was presented May 13 to John W. Newton, of Beaumont, Tex., recently retired vice president of Magnolia Petroleum Co.

The presentation was recognition of his many years of service to the petroleum industry, and of his many activities with the Division of Refining of the American Petroleum Institute, which held its 22nd midyear meeting here in Philadelphia.

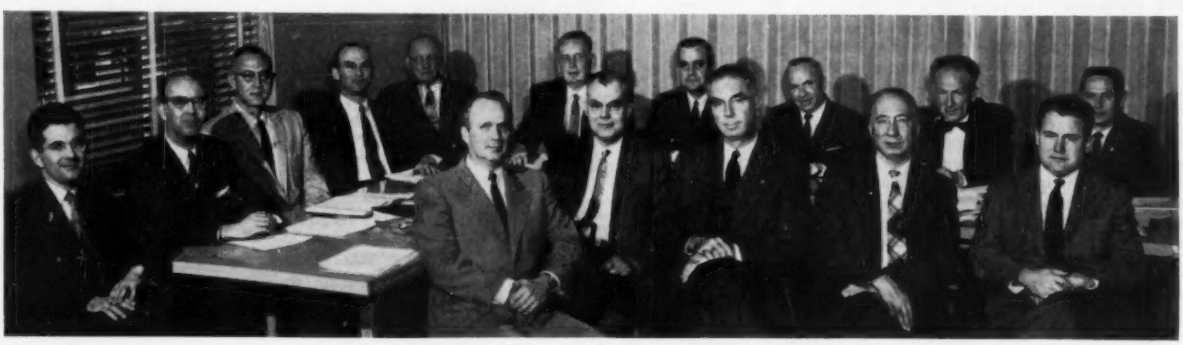
It was given to him by his colleagues on the Refining Division's General Committee—the group which sets policy and procedures for the division.

William Naden, of Esso Standard Oil Co., New York, made the formal presentation on behalf of the committee members at a reception and dinner.

E.C. Hughes Assumes Chairmanship of API Research Project 45

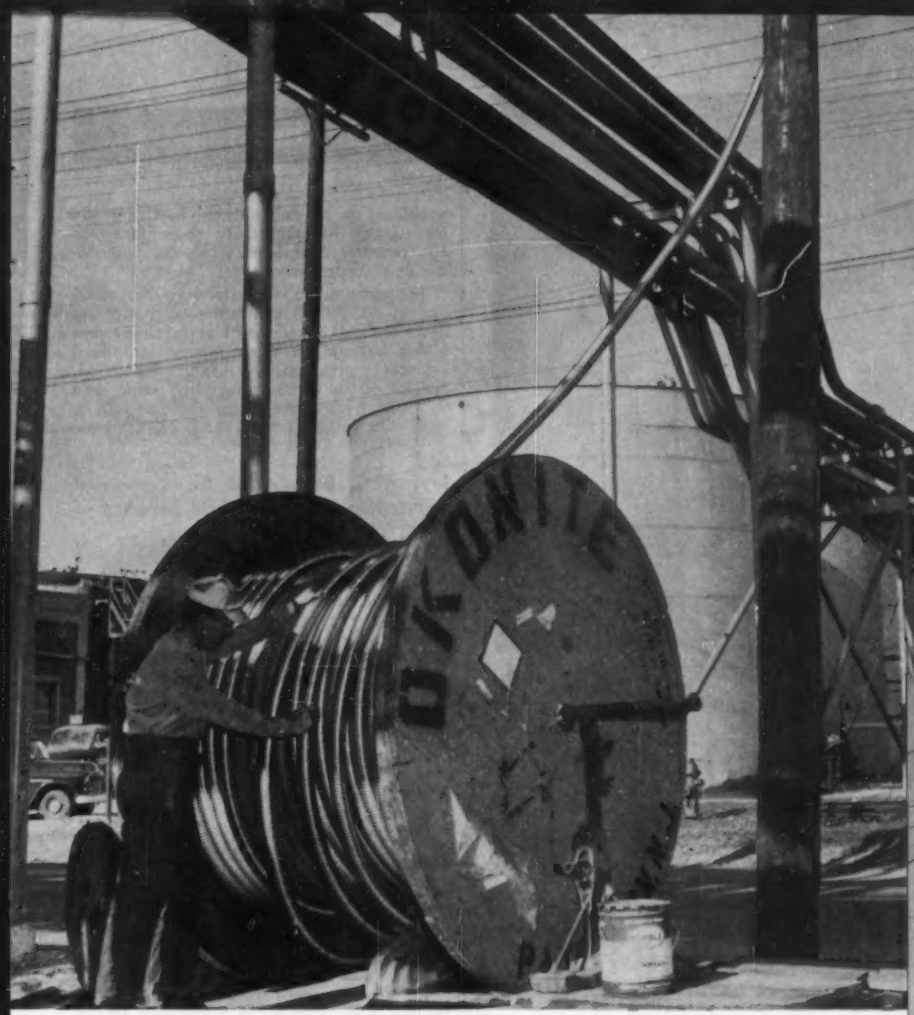
The American Petroleum Institute Research Project 45 (APIRP-45), on the "Synthesis, Purification and Properties of Hydrocarbons of Low Molecular Weight," will complete its nineteenth year of operation, under the direction of Professor Cecil E. Boord at the Ohio State University, on June 30, 1957. The accompanying picture was taken at a recent meeting of the Project's Advisory Committee, at which time Dr. E. C. Hughes, the Standard Oil Co. (Ohio) officially accepted the chairmanship of that committee from Dr. Wheeler G. Lovell, Ethyl Corp., the retiring chairman. The project's advisory committee is composed of ten men from industrial research laboratories throughout the country. It meets two to four times per year to review the work which the project has done in the interim period and to offer guidance and advice on future work.

APIRP-45 has recently completed the knock-testing of 368 pure hydrocarbons, most of them having been synthetically produced on the one to three gallon scale. The data (over 7500) resulting from this study comprise the largest body of strictly comparable knock-test data existing in the world today and have permitted correlation of the molecular structures of hydrocarbons with their knock resistance. The American Society for Testing Materials is in process of publishing these data and correlations as a Special Technical Publication. APIRP-45 is now embarking on a study which it hopes will establish the fundmental principles and means for predicting the knocking behavior of mixtures of pure hydrocarbons. Interaction in such mixtures causes their knock ratings to vary substantially from those which would be predicted by assuming a linear relationship among the components. The



Advisory Committee Meeting for API Research Project 45

Back row left to right: E. J. Y. Scott, Socony-Mobil; Louis Schmerling, Universal Oil Products; J. M. Derfer, K. W. Greenlee, and C. E. Board, Ohio State University; E. C. Hughes, The Standard Oil Co. (Ohio); W. G. Lovell, Ethyl Corp.; L. C. Beard, Jr., Socony-Mobil; G. H. Denison, California Research Corp.; and R. A. Randall, General Motors. Front row left to right: L. L. Stout, Ohio State University Research Foundation; E. O. Mattocks, API; S. S. Shaffer, Humble Oil & Refining Co.; F. E. Frey, Phillips Petroleum Co.; and N. D. Coggeshall, Gulf Research and Development. Members not pictured: W. A. Herbst, Esso Research and Engineering, and B. M. Sturgis, E. I. duPont de Nemours.



Installing 15,000-volt Loxarmor feeder (above). Single pulls as long as 1,600 feet were made around corners (right) without re-sorting to splices. A half-inch stainless steel messenger was used.

15kv Loxarmor® aerial feeders replace bare wires at refinery

In replacing bare wire aerial feeders that had proved unreliable in bad weather and had, on several occasions, shorted out and burned down, a Texas refinery installed nearly 8,000 feet of Okonite oil-impregnated, paper-insulated, lead-sheathed Loxarmor cable. Protected with an interlocking S-shaped bronze armor (Loxarmor), this cable has proved itself 100% reliable. The Loxarmor provides mechanical protection against movable drag lines, cranes, and the like.

Here is one example of how industry uses versatile Loxarmor cable—the modern conduit-type cable that's mechanically strong, flexible and versatile. For either power or control circuits, Loxarmor cable has proved itself time and again to be economical . . . easy to install indoors or outdoors . . . easy to move and re-route . . . easy to inspect and maintain . . . completely reliable and dependable.

Loxarmor can be supplied over any standard Okonite insulation, rubber, plastic, paper or varnished cambric—depending upon your installation conditions and voltage requirements. It is available in galvanized or stainless steel, aluminum or bronze. For full details, contact your local Okonite representative or write to The Okonite Company, Passaic, New Jersey.

where there's electrical power . . . there's **OKONITE CABLE**

4845

Centrifugally Cast Pipe is STRONG Pipe.....

Planning to install high pressure lines in your plant? Will they carry hot corrosive liquids or gases?

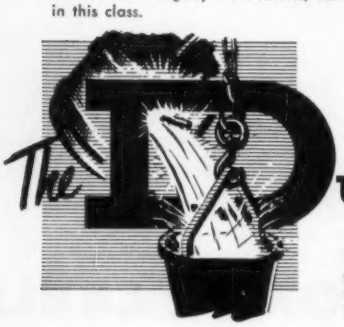
You will find SAFETY in DURASPUN Centrifugally Cast Pipe. It's very strong, with strength approaching that of forged steel. It can be alloyed to give you maximum resistance to the heat and corrosion to be encountered.

.it's alloyed to resist corrosion and high temperature

DURASPUN Pipe comes in a wide range, as follows:

Outside Diameter	Minimum Wall	Length
2½" to 3"	1/4"	88" maximum
3" to 6" Inclusive	5/16"	110" maximum
Over 6" to 12" Inclusive	3/8"	168" maximum, 24" minimum
Over 12" to 14" Inclusive	7/16"	168" maximum, 24" minimum
Over 14" to 20" Inclusive	1/2"	180" maximum, 48" minimum
Over 20" to 24" Inclusive	1/2"	88" maximum
Over 24" to 32" Inclusive	5/8"	80" maximum

This is standard piping. Special cylindrical shapes in comparable high alloy steel can be cast centrifugally . . . retorts, furnaces, fractionaters and other such equipment come in this class.



Write us about your requirements. Our metallurgists backed by thirty-five years of experience will be glad to help select the best combination of alloying elements to take care of your operating conditions.

The DURALOY Company

OFFICE AND PLANT: Scottdale, Pa.

EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

Men in the Industry . . .

problems to be encountered in this study far exceed in complexity those faced in the recently completed study on pure individual hydrocarbons.

In addition to the activities described above, APIRP-45 synthesizes and supplies hydrocarbons to the API research project 6 for use in its high purity (standard samples) program. By June 30, 1957, APIRP-45 will have supplied over 165 different hydrocarbons for this purpose in total amount of better than 220 gallons.

Irving C. Brown has been appointed manager of the Bakersfield refinery of Standard Oil Co. of California, Western Operations, Inc. Brown succeeds **L. L. Henning** who has been transferred to San Francisco on special assignment.

Brown

A native of Michigan, Brown joined Standard in July of 1938 as an engineer immediately after his graduation from University of Michigan where he earned a B.S. degree in chemical engineering. After wartime service at El Segundo, he was named general foreman of the cracking division there in 1947.

In June of 1953 he was named assistant superintendent at Richmond and was promoted to superintendent in 1955.

Gordon R. King has established offices as a consulting engineer in Amarillo, Texas.

King

For the past ten years, King has been associated with Humble Oil & Refining Co., at its Baytown, Texas refinery. When he left, he held the position of senior mechanical engineer.

King received his B.S. degree in mechanical engineering from Southern Methodist University, and his M.S. degree from the University of Texas. While he was studying for his M.S. degree, he spent one year as an instructor in the school of engineering.

King is a registered professional engineer in Texas, and is a member of the American Society of Mechanical Engineers and the National Association of Corrosion Engineers. He is a former author of PETROLEUM REFINER, having had two articles published last year.

Dr. Kenneth Merle Watson, former vice president of The Pure Oil Co., has been appointed to the staff of Illinois Institute of Technology, Chicago. Watson will teach and do research in kinetics and thermodynamics in the chemical engineering department.

He was director of research at The Pure Oil Co. before becoming vice presi-

For more data on advertised products, use Readers' Service Cards, last page.

SOLID WHEEL

spells non-stop turbine performance

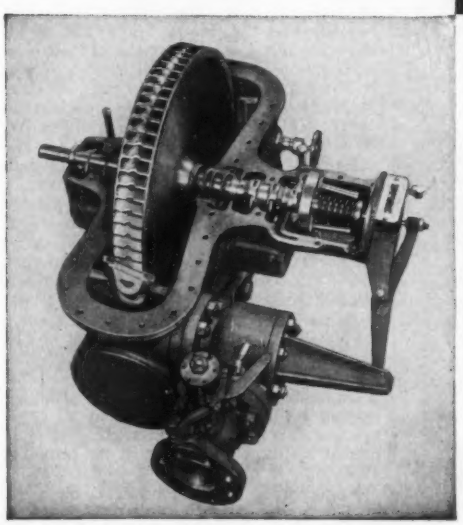
It's easy to see why Terry solid-wheel turbines have been setting non-stop records. They're built for long periods of continuous service.

The rotor, for example, is a single forging of special composition steel, in which a series of semi-circular buckets is milled. There are no separate parts to loosen or work out.

What's more, the blades can't foul. There is a one-inch clearance on either side of the wheel and the blades are double rim protected. There is no need for close axial blade clearance, because the steam enters the buckets at right angles to the shaft.

You, too, can profit from Terry solid-wheel stamina. Bulletin S-116 gives full details. Send for a copy today.

THE TERRY STEAM TURBINE CO.
Terry Square, Hartford 1, Conn.



Action of steam in a Terry solid-wheel turbine. The steam issues from an expanding nozzle at high velocity and enters the side of the wheel bucket where its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is caught in a stationary reversing chamber and returned again to the wheel. This process is repeated several times until practically all of the useful energy has been utilized.

TT-1205

TERRY

For more data on advertised products, use Readers' Service Cards, last page.

rapid
short flame combustion
...even on residual fuel oil

THERMAL

VORTEX BURNER

Here is a versatile unit that gives rapid, clean combustion on a wide range of fuels including Bunker C, No. 6, light oil, any gas . . . even liquid organic wastes.

Combustion is 80% completed within the burner itself and takes place with a whirling, short flame that attains heat release rates of over 1,000,000 BTU/hr per cu ft. Products of combustion are clean and sufficient excess air for tempering the products may be introduced through the burner itself without causing smoke or instability.

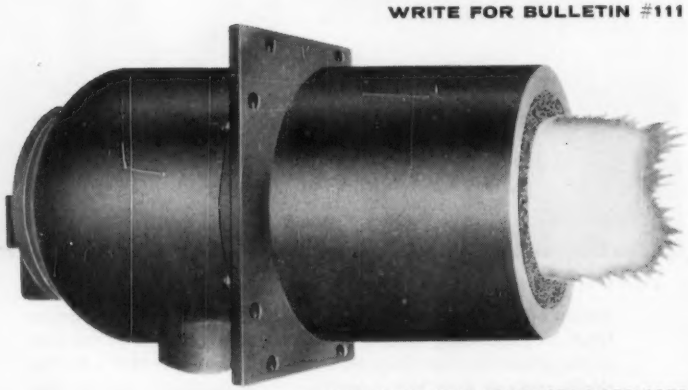
standard models available...

Complete units from 3,500,000 BTU/hr to 50,000,000 BTU/hr are available and may be fitted for steam, compressed air or mechanical atomization. With dual fuel arrangements switching from gas to oil is accomplished without shutdown.

instant ignition...

Gas-electric or torch ignition allows full ignition in a few seconds—even with a cold burner.

WRITE FOR BULLETIN #111



OTHER THERMAL PRODUCTS & SERVICES

Gas, Oil & Combination Gas-Oil Burners • Heat Exchangers • Air Heaters • Submerged Combustion • Gas Generators • Combustion & Heat Transfer Engineering

THERMAL

Thermal Research & Engineering Corp.

CONSHOHOCKEN • PENNSYLVANIA

REPRESENTATIVES IN PRINCIPAL CITIES

Men in the Industry . . .

dent in 1954. He has been a consultant to industry and, from 1941-1942, he was engineering coordinator at Gulf Oil Corp.

From 1931 to 1941 Watson was director of engineering research for Universal Oil Products Co. He also was assistant engineer in Western Electric's development laboratories.

He was a research professor at the University of Wisconsin from 1942-1949. Before that time he served the university as an instructor and an assistant professor.

Watson received his B.S., M.S. and Ph.D. degrees in chemical engineering from the University of Wisconsin, where he also did advanced study in physical chemistry.

Smith

Graves

Adam

Bradshaw

P. L. Smith has been named manager of Magnolia Petroleum Co.'s Refining division, and **F. M. Graves** has been promoted to assistant general manager, Refining division. **R. C. Adam** has replaced Smith as manager of operations at the company's large Beaumont refinery, and **W. M. Bradshaw** has been named executive assistant.

The four-man move was announced by **R. G. Sanders,** who was earlier named a Magnolia director and vice-president in charge of refining to succeed **John W. Newton** who retired May 1.

Graves was executive assistant and Adam was manager of technical services.

Smith's new position places him directly in charge of administering all phases of operations at the refinery. He has served as manager of operations since January, 1956. Prior to that, he directed the refinery's Technical department for 17 years.

As assistant manager, Graves will move up from the executive assistant post he has held since October, 1956. He is a 22-year veteran of the company, having joined the plant laboratories in June, 1935, after receiving his B.S. degree in chemical engineering from Texas A. & M. He was named assistant chief chemist in January, 1939.

Adam, upon his promotion to manager of operations, will have served as manager

For more data on advertised products, use Readers' Service Cards, last page.

When Mathieson DIETHLYENE GLYCOL is there

Keeping gas dry is a "pipe" for Mathieson Diethylene Glycol. Its remarkable ability to absorb moisture makes it a leading agent for checking rust and corrosion in gas lines.

Meeting your most exacting requirements of quality and supply, Mathieson Diethylene Glycol is available in tank cars, tank trucks and resin-lined drums from our plant at Brandenburg, Ky., or from distribution points in key areas. Contact your Olin Mathieson representative today for full information.

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OLIN MATHIESON CHEMICAL CORPORATION
INDUSTRIAL CHEMICALS DIVISION • BALTIMORE 3, MD.

the gas stays on

MATHIESON

INORGANICS: Ammonia • Bicarbonate of Soda • Carbon Dioxide • Caustic Potash • Caustic Soda • Chlorine • Hydrazine and Derivatives • Hypochlorite Products • Muriatic Acid • Nitrate of Soda • Nitric Acid • Soda Ash • Sodium Chlorite Products • Sulfate of Alumina • Sulfur (Processed) • Sulfuric Acid
ORGANICS: Ethylene Oxide • Ethylene Glycols • Polyethylene Glycols • Glycol Ether Solvents • Ethylene Dichloride • Dichloroethylether • Formaldehyde • Methanol Sodium Methylate • Hexamine • Ethylene Diamine • Polyamines • Ethanolamines • Trichlorophenol • Surfactants

4895

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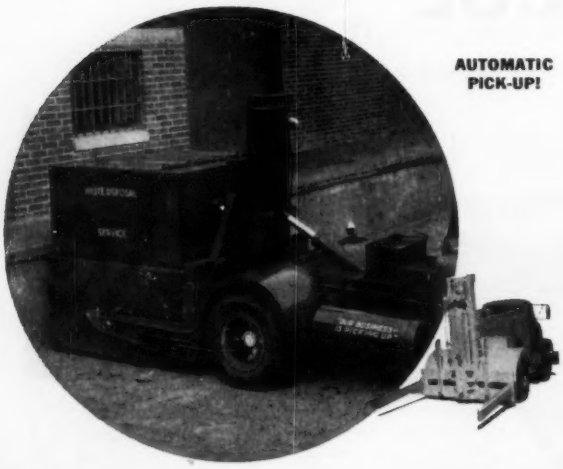
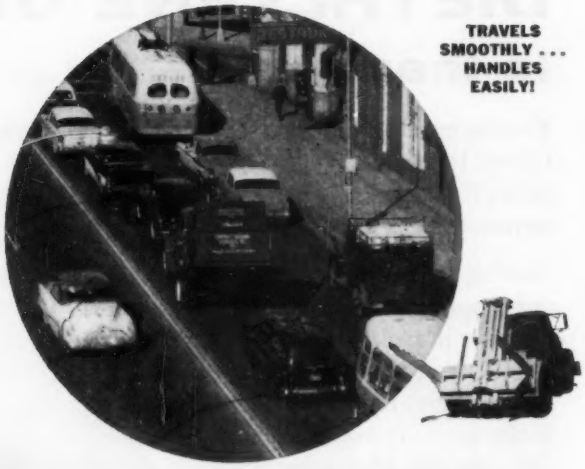
Here's Another New Development from Dempster Brothers to cut

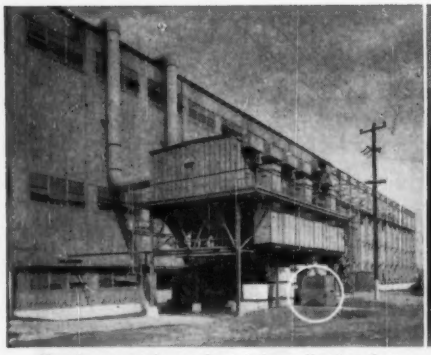
Now Automatic Pick-Up of Dempster-Dumpster



AUTOMATIC PICK-UP!



TRAVELS SMOOTHLY . . . HANDLES EASILY!

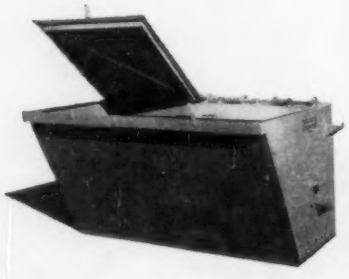


Here's a container adapted for collecting dust from two 75-ton furnaces.

Containers can be served inside buildings.

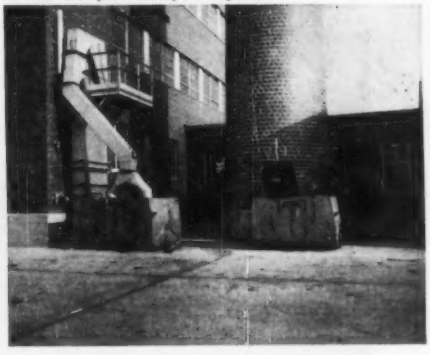
Dempster-Dumpster handles extremely heavy materials like this Fullers Earth.

Sump Bottom Containers are available. This leak-proof feature is desirable wherever moist, liquid and wet refuse is a problem.



Tilt Type Containers for handling liquid and solid materials are available.

Adaptation like this one for handling cinders from furnaces illustrate another flexibility advantage of the Dempster-Dumpster system.



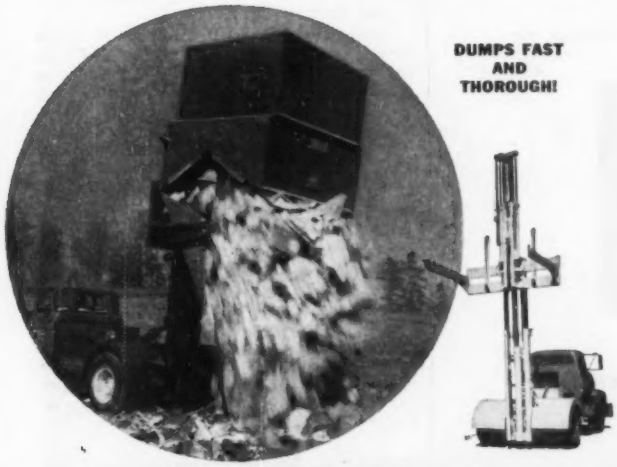
THE DEMPSTER DUMPSTER® SYSTEM

DEMPSTER BROTHERS

567 Dempster Building, Knoxville 17, Tennessee

Materials Handling Cost in Refineries - - -

Containers— Driver Never Leaves the Cab!



DUMPS FAST AND THOROUGH!

Here is an achievement that leaves little, if anything, to be desired in the handling of bulk loads with big steel Dempster-Dumpster Detachable Containers . . . another flexibility advantage available only in the Dempster-Dumpster System! The GRD 304-F-2 is a truck-mounted Dempster-Dumpster with fork-like arms. It enables containers to be picked-up, hauled, dumped and returned to location without driver ever leaving cab. All this, plus shorter turning and maneuvering area requirements, and plus high dumping — a versatile range of dumping heights up to approximately 11'. This new Dempster-Dumpster offers many advantages for speeding-up handling of bulk material loads in big Dempster-Dumpster Detachable Containers that are worth consideration in your plant now! Write us today for complete literature on this new Dempster-Dumpster. Or, if your operation would require greater payload handling capacities, ask us about our Dempster-Dumpsters built to handle payloads up to and over 36,000 pounds, plus detachable containers up to 21 cubic yards in size. Manufactured by Dempster Brothers, Inc.

And services Skip Type Containers having required bale.

Acid materials like these stripped battery cases are just a sample of the type of wastes handled.

Many Standard and Special Tank Type Containers for handling liquids, chemicals, oils, etc., are available.

Big 15-yard Universal Containers are available. Note the area of the top opening. Standing in the container you would see the view as camera pictures it at right below. "Like trying to fill a bottomless pit," report many happy users.

DEMPSTER BROTHERS
creative engineers
successfully exploring new ideas to reduce your materials handling costs with the.....
DEMPSTER DUMPSTER SYSTEM

Clip and mail this coupon for FREE LITERATURE!

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CITY _____ STATE _____

Please send me folder on the new Dempster-Dumpster GRD 304-F-2 and the Dempster-Dumpster System.

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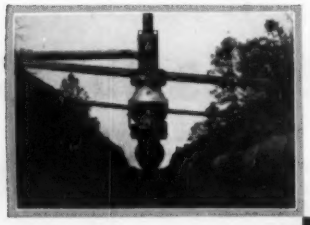
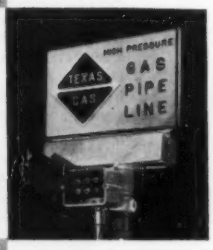


STOPPLE APPLICATION
HOT TAPPING
PIGGING
BUSHINGS & INSULATORS

Agent for T. D. Williamson, Inc.

MARKER VENTS
AERIAL MARKERS
WELL MARKERS
SAFETY SIGNS

Sole Distributors for L & M Co.

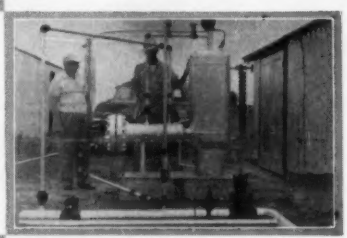


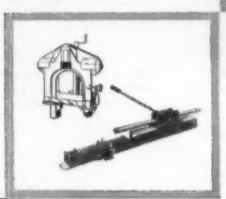
ASPHALT OUTERWRAP
ASPHALT COATING
ROCK SHIELD

Agent for Gulf States Asphalt Co.

H & H GAS ODORIZERS
Built to your specifications

Manufactured by Tod Pazdral





GUILLOTINE SAWS
NATIONAL SAWS

Agent for E. H. Wachs Co.

MERCURY HYDRAULIC
PIPE PUSHERS

Tell 'Em
We'll Be There!

You can depend on Topaz sales engineers to be on the job—on time—working in cooperation with your engineering department. Topaz service includes furnishing all equipment on a lease, contract or purchase basis. Call Topaz day or night . . . we'll be there!

TOD PAZDRAL — ToPaz

PIPELINE SPECIALTIES

2525 South Boulevard • Houston 6, Texas
Day Phone JA 2-1403 • Night Phone MA 3-5680

Men in the Industry . . .

of technical services for one and one-half years. He was moved up to that post in January, 1956, from chief process engineer in the Technical department.

Bradshaw, a long time resident of Beaumont, joined the refinery in May, 1921, in the pipe shop. In April, 1941, became a statistician in the Economics department, and in January, 1949, he was transferred to the general superintendent's office where he was later promoted to staff assistant. He was named aide to Graves in October, 1956.

James L. Walker has joined Purvin & Gertz, Inc., consulting engineers, in Dallas. Walker was formerly associated with Humble Oil and Refining Co. in the Technical Service division at the Baytown refinery. He received the B.S. degree in chemical engineering from the University of Texas in 1937. With Purvin & Gertz, Inc., he will serve as a staff consultant for the petroleum refining and petrochemical industries.

Robert A. Sailor, technologist with the Research and Development laboratory of Socony Mobil Oil Co., Inc., Paulsboro, N. J., has been named this year's winner of Socony Mobil's annual incentive fellowship award.

The fellowship was established in 1947 to enable laboratory employees with outstanding ability and proficiency in science and inventiveness to further their academic training.

The full salary of the award winner continues for a period of up to three years while he carries on advanced studies. An unrestricted grant of $750 is also given annually to the university selected by the award winner to aid in defraying the full cost of his education. Sailor plans to work toward his Ph.D. degree in chemical engineering at the University of Delaware.

Sailor was born in Drexel Hill, Pa. After serving as an Aviation Midshipman, 2nd Class, in the U. S. Navy between 1947 and 1950, he received a B.S. degree in chemical engineering at Lehigh University.

James M. Gill has been appointed manager of the new Ethyl Corp. manufacturing plant under construction at Pittsburg, Calif. Gill will make his headquarters at the plant site in Pittsburg.

A native of Ruston, La., Gill has been associated with Ethyl since 1948 and has been located at its Baton Rouge plant. Starting as a chemical engineer in the manufacturing department, he became head of manufacturing technical services of the former research and engineering department in 1951, and two years later was named acting supervisor of the ethyl chloride operations at the plant.

From 1955 until September, 1956, he served as acting general superintendent of maintenance and on-plant construction at the Baton Rouge plant.

Gill holds a B.S. degree in chemical engineering from Louisiana Polytechnic Institute and an M.S. degree in chemical engineering from Louisiana State University.

Lee A. Whitney, formerly vice president—refining, has been named vice president and coordinator of manufacturing and marketing of Champlin Oil & Refin-

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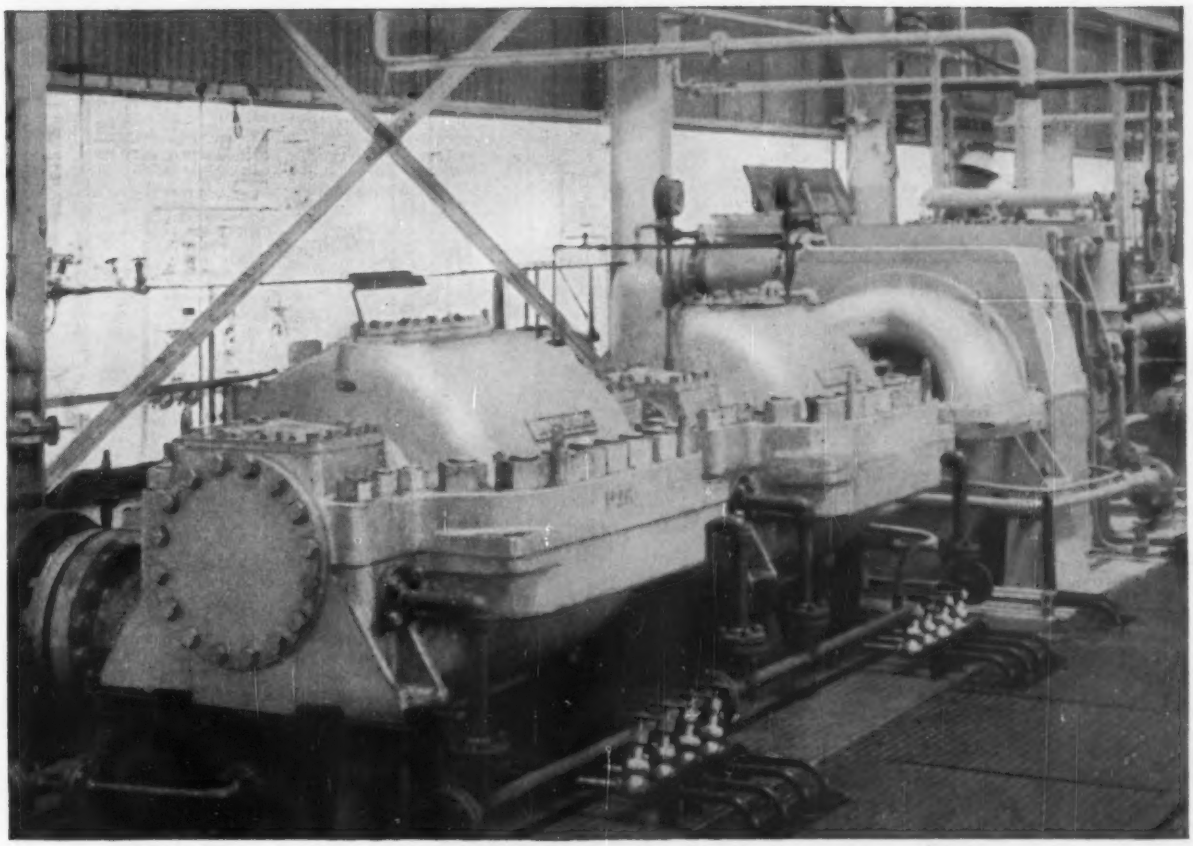


Centrifugal Compressors (shown before lagging) for handling ethylene for cascade refrigeration in separation unit. Compressors are built to deliver liquefied ethylene after condensation at 270 psi absolute. The housings are cast of a 3½% nickel steel that exceeds minimum 15 ft.-lb. Charpy impact test requirements at −150°F. Built by Ingersoll-Rand, New York, N. Y.

Ethylene refrigerating compressors at Gulf Oil...

Nickel steel casings a "must" for toughness down to −150°F

Compressors used in cascade refrigeration handling ethylene at Gulf Oil's Port Arthur, Texas, No. 2 Plant need the properties provided by a 3½% nickel cast steel.

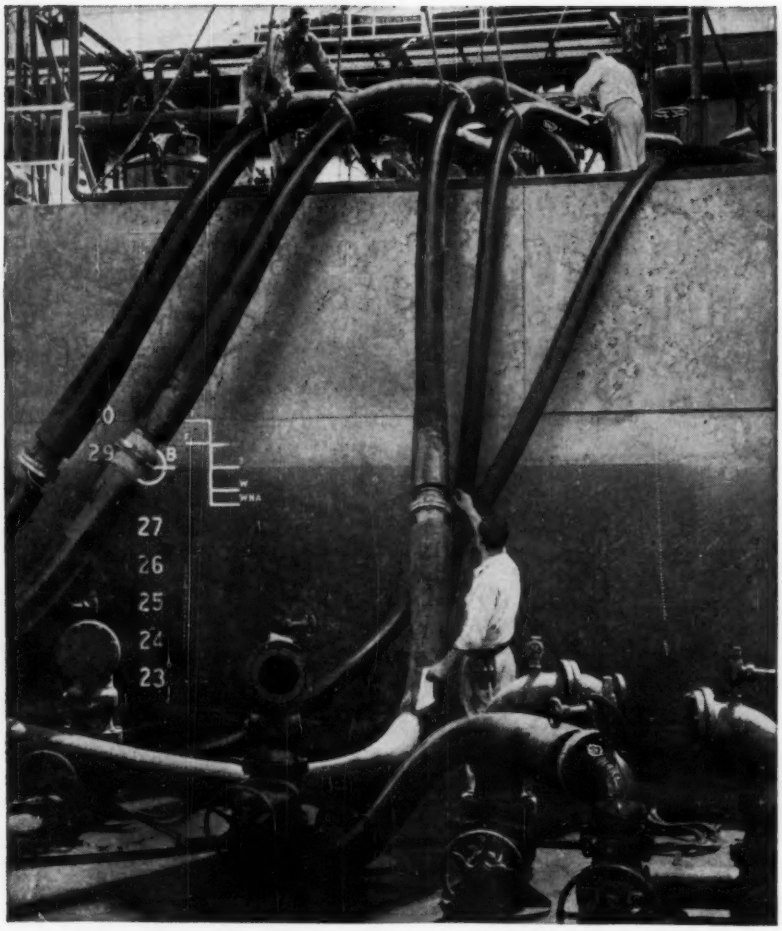
That's because this nickel steel meets ASTM A 352-52T requirements. It resists embrittlement right on down to —150°F.

But toughness at subzero temperatures is only one reason why nickel cast steel is a "must" for this kind of job.

It also provides adequate strength and excellent ductility at normal temperatures, and meets the need for a high degree of pressure tightness. Should Gulf Oil ever need it, the steel has good response to welding and other fabricating operations.

Investigate nickel alloy steels for your temperature problem: high or low. There's a grade that's right for your equipment. And Inco will be happy to help you select it. Just write and include details.

INCO TRADE MARK THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.



NEW QUAKER HOSE

for loading and unloading oil and gasoline from barges and tankers!

- *Won't kink or crush!*
- *Won't expand under pressure!*
- *Won't collapse under suction!*
- *Superior construction due to nylon cord reinforcement!*

For more information about new Quaker Qua-Flex Oil Transportation Hose—flexible, lightweight and rugged—see your Quaker Rubber distributor today!

Or write:
Quaker Rubber Division,
H. K. Porter Company, Inc.,
Philadelphia 24, Pa.

HKP QUAKER RUBBER DIVISION
H. K. PORTER COMPANY, INC.

Men in the Industry . . .

ing Co. **Earl M. Beebe,** formerly refinery manager for the company's Enid, Okla., refinery, has been named manager of refining and will move to Fort Worth. **J. E. Mohundro,** formerly process engineer, has been named superintendent of the Enid refinery.

Bruce S. Ainsworth has been named manager of the Chemical division Application Laboratory at the Summit, N. J., research laboratories of Celanese Corp. of America. He succeeds **Dr. Michael J. Curry** who recently was made laboratory manager of Summit's plastics and chemical research facilities.

Ainsworth

Ainsworth joined Celanese in 1945 as a production department supervisor at the Bishop, Texas, chemical plant. He served in various process and production assignments at the Bishop plant until 1954 when he was transferred to Chemical division headquarters in New York City as coordinator of product development activities.

Born in Reagan, Texas, Ainsworth is a graduate of Baylor University where he received his M.S. in chemistry in 1940. He is a former secretary and chairman of the South Texas Section of the American Chemical Society.

R. E. Lenz has been named manager of Monsanto Chemical Co.'s newly organized systems engineering section, which will study the dynamics of chemical process systems and their control.

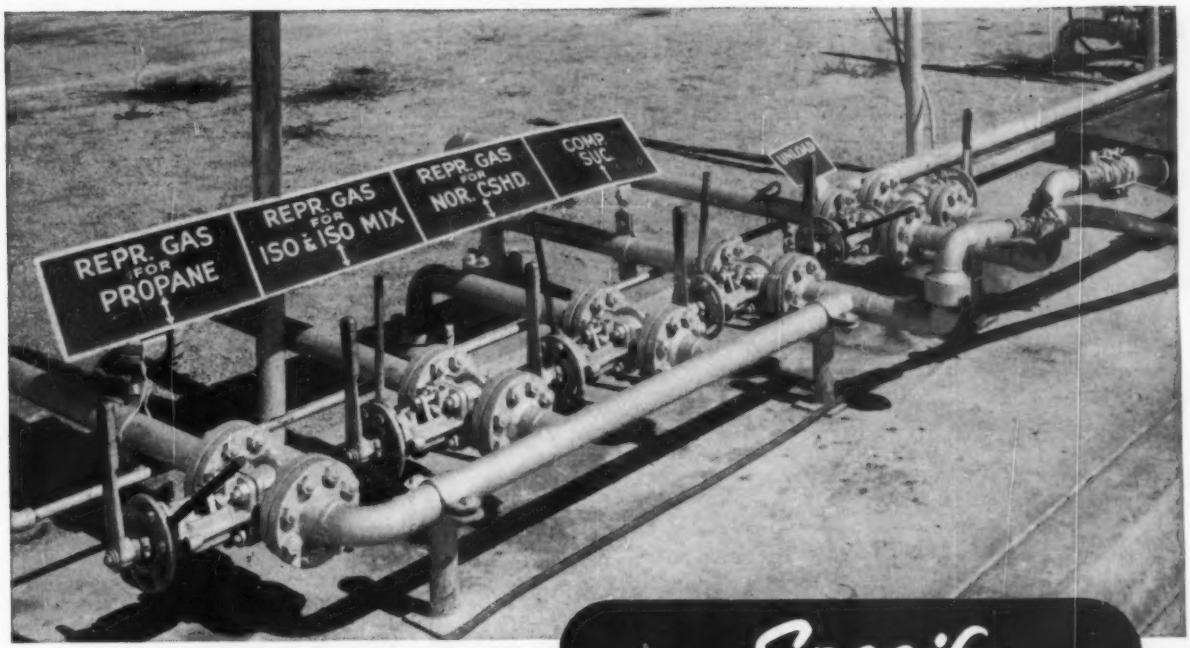
Group leaders already engaged in carrying on work of the section include **Dr. Joel O. Hougen,** formerly professor of chemical engineering at Rensselaer Polytechnic Institute, and **Dr. Theodore J. Williams,** formerly assistant professor of chemical engineering at the U. S. Air Force Institute of Technology, both of whom have published articles in this field; **William J. Katt,** formerly manager of the instrumentation and electrical engineering section of Monsanto's Organic Chemicals division; and **Milton Welhoelter,** senior technologist with the R. & E. division and formerly chief engineer of Monsanto's Atomic Electric Project.

Edward D. Mellinger has been named editor of the American Petroleum Institute *Quarterly,* it was announced by H. B. Miller, director of the Department of Information.

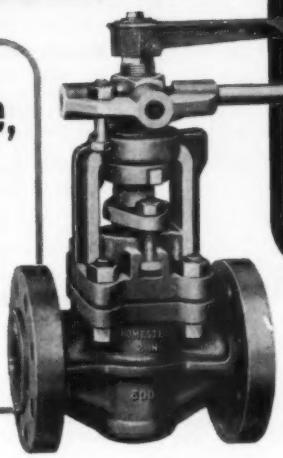
Mellinger, who had been serving as consulting editor, succeeds Walter Henry Nelson, who has resigned. Mellinger has been with the Institute since 1948.

Harold S. Bell, after world-wide experience in the petroleum field, has opened an office as a consulting engineer at 744 Broad St., Newark, N. J., giving particular attention to tankmanship matters, shore installations, and off loading and loading of vessels. Bulk terminals will receive his special attention. Bell is the author of *American Petroleum Refining* now in re-

For more data on advertised products, use Readers' Service Cards, last page.



for dependable, trouble-free control of "hard-to-hold" fluids . . .



Specify HOMESTEAD Lever-Seald VALVES

they provide sure shut-off...

ARE STICK PROOF...OPERATE INSTANTLY

A positive, drop-tight seal and instant, stick-proof operation under all fluid, temperature or pressure conditions, is assured by the exclusive, built-in, Homestead Lever-Seald mechanism. This powerful lever-and-screw device not only presses the valve's tapered plug firmly into its seat to form a drop-tight seal, but also provides a positive means of relieving seating pressure just enough to overcome friction and permit easy operation. And because all operating parts and valve seating surfaces are fully protected in both the open and closed positions from the corrosive or erosive effects of line fluids, long, dependable, trouble-free service is doubly assured.

If "hard-to-handle" fluids are your problem, specify Homestead Lever-Seald Valves for your next installation or as replacements. You'll be glad you did.

We make them in metals and alloys to specification in sizes 1½" to 12", for pressures from vacuum to 1500 lbs., and for temperatures from 40° below zero to 1100°F. Dry seat, or pressure gun lubricated optional.

For complete details and copy of VALVE REFERENCE BOOK No. 39-3, MAIL THE COUPON TODAY.

HOMESTEAD
VALVE MANUFACTURING COMPANY
"Serving Since 1892"
P. O. BOX 45 CORAOPOLIS, PA.

Without obligation, send me Catalog 39-3 covering Homestead Lever-Seald Valves.

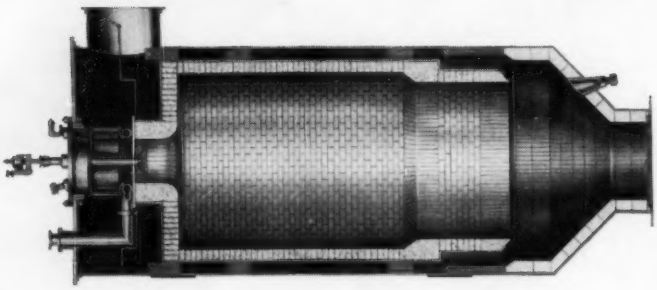
NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

The PEABODY Direct-Fired Air Heater Furnace is



Compact
Oriented to suit
Multi-fuel
Pressurized
Efficient
Time tested
Economical
Nameplate of quality
Tailored to job

to

solve your air heater problems

Hundreds of Peabody Direct-Fired Air Heaters are delivering the heat that never fails in petroleum refineries and process industries all over the world—the sun never sets on Peabody Air Heaters.

PEABODY ENGINEERING CORPORATION

232 MADISON AVENUE, NEW YORK 16, N. Y.

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PEABODY LIMITED • LONDON, S.W. 1, ENGLAND

7-094

Men in the Industry . . .

vision for a fourth edition, and *Oil Shales and Shale Oils*, together with miscellaneous technical papers and articles.

Fred Powell has been appointed a vice president and director of Standard Oil Co. of California, Western Operations, Inc.

Powell

Powell, heretofore manager of the Western Operations, Inc. Manufacturing department, joined Standard in 1925 and previously served as manager of the company's El Segundo refinery and as assistant manager of Manufacturing.

He was also formerly president of California Research and Development Corp., a now-dissolved Standard subsidiary. A native of Portland, Powell is a graduate of the University of Washington.

Royes Salmon has joined the engineering department of Houdry Process Corp. as a senior process engineer.

Salmon had previously been with Union Oil Co.'s research center in Brea, Calif., as a senior process engineer. Prior to this, he was associated with Foster Wheeler Corp. in New York.

He is a graduate of Cooper Union Institute of Technology and served in the Navy during World War II.

Emmett J. Berg, formerly with Great American Oil Company, has joined Kerr-McGee Oil Industries, Inc., as planning and design engineer. Berg was employed by Deep Rock Oil Corp. from 1937 to 1951, at which time he joined Great American, Deep Rock's Chicago distributor. Kerr-McGee bought Deep Rock in 1955.

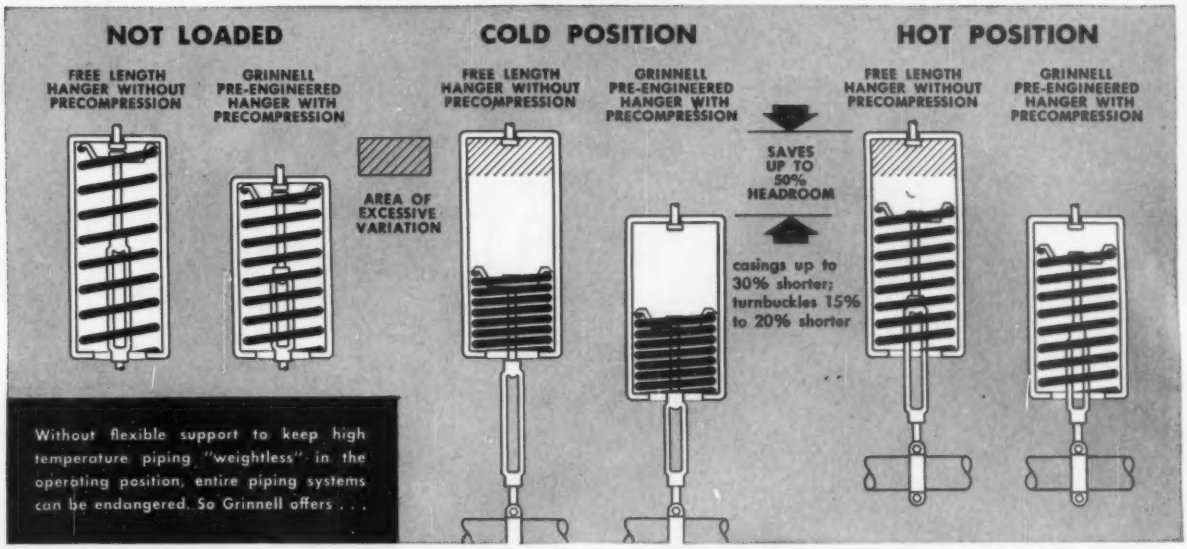
Dr. L. H. Sutherland has been appointed section head in the research program of Escambia Chemical Corp. Dr. Sutherland will be in charge of the analytical and certain of the process groups. His activities will be divided between Cambridge and Newton, Mass., where Escambia presently has its research and technical service facilities.

From American Cyanamid Co. in New Orleans, where he was chief development chemist, Dr. Sutherland joined the Escambia group at National Research Corp. January 1, 1956. He obtained his A.B. degree from Dartmouth and his M.S. and Ph.D. degrees in organic chemistry from Pennsylvania State University. He is a member of the American Chemical Society.

Dr. Bernard M. Sturgis, director of the Du Pont Co.'s petroleum laboratory, Deepwater Point, N. J., has been appointed to the National Advisory Committee for Aeronautics subcommittee for aircraft fuels.

Subcommittees of the NACA assist in

For more data on advertised products, use Readers' Service Cards, last page.


NOT LOADED
COLD POSITION
HOT POSITION
FREE LENGTH HANGER WITHOUT PRECOMPRESSION
GRINNELL PRE-ENGINEERED HANGER WITH PRECOMPRESSION
AREA OF EXCESSIVE VARIATION
FREE LENGTH HANGER WITHOUT PRECOMPRESSION
GRINNELL PRE-ENGINEERED HANGER WITH PRECOMPRESSION
SAVES UP TO 50% HEADROOM
casings up to 30% shorter; turnbuckles 15% to 20% shorter
FREE LENGTH HANGER WITHOUT PRECOMPRESSION
GRINNELL PRE-ENGINEERED HANGER WITH PRECOMPRESSION
Without flexible support to keep high temperature piping "weightless" in the operating position, entire piping systems can be endangered. So Grinnell offers . . .

Precompressed Hangers for Safer Support of Piping

Helical coil springs are widely used in hangers for flexible support of piping which moves up or down during thermal expansion. The A.S.A. code for pressure piping requires that variable spring hangers support at least a minimum of 75% of the pipe's weight for a pipe that rises (relaxing the spring) and no more than 125% of the pipe's weight for a pipe that lowers (compressing the spring) during operation.

Precompression patented Grinnell principle

To guard against the spring's supporting force exceeding the limits of variation, Grinnell developed and patented a variable spring hanger design. The steel casing holds the spring permanently precompressed, at the threshold of the hanger's working load range. This prevents the spring decompressing into its area of excessive variation.

Pre-set is not a substitute

As a partial substitute for this patented precompression, some manufacturers insert a spacer between the top end of a free-length hanger casing and the spring to hold the spring's height temporarily within the working range during shipment and erection.

Another device requires the manufacturer to drill symmetrically opposite holes in the casing walls and insert a bolt to hold the spring's height within the working range. When these devices are removed from the hanger and discarded, the spring can decompress, resulting in high variability in supporting force.

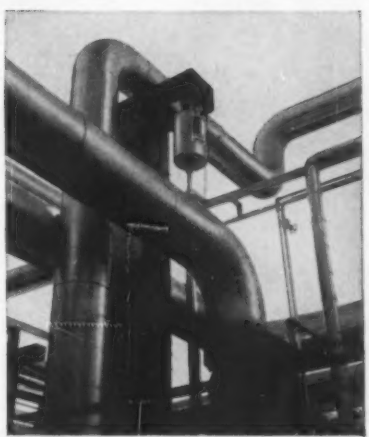
Cold-setting a universal factory service

For the erection crew to avoid having to compress the spring down to the erected position, the manufacturer can compress the spring down to this height. Grinnell can provide a cold-set bolt in precompressed hangers.

Less headroom required by Grinnell Hangers

Shorter hanger casings made possible by Grinnell's patented precompression, reduce bulk shipping weight and required headroom by eliminating undesirable height. Installation is simplified by this shorter casing and also by an integral load scale with load indicator.

Additional headroom is saved by a correspondingly shorter turnbuckle. These precompression advantages are available in short spring and double spring models as well as standard spring models.



Refinery piping supported safely, with ample flexibility but low headroom.

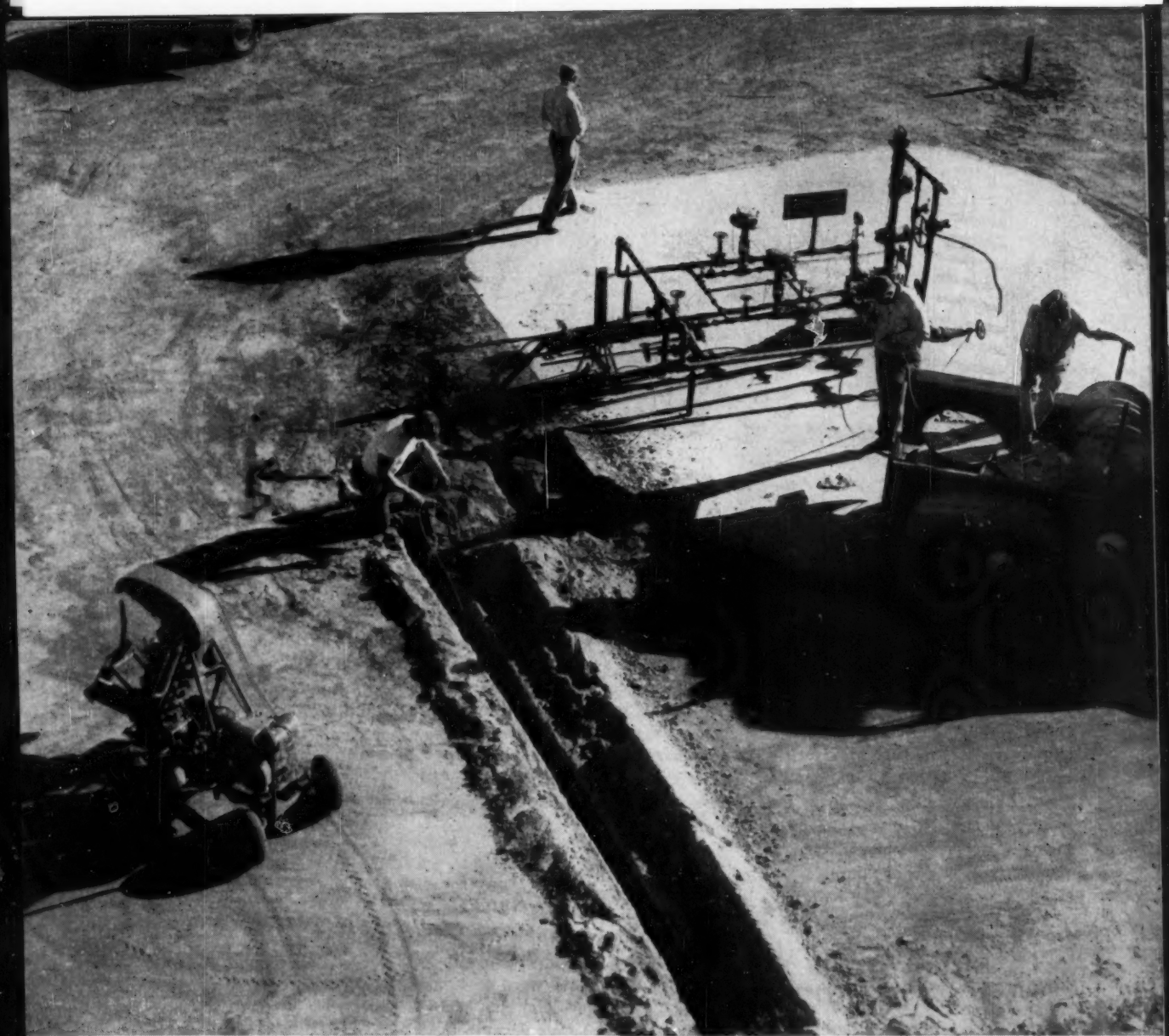
Available in 63 standard units

Grinnell Variable Spring Hangers are available in 21 sizes each of short, standard and double spring models . . . for maximum travel of 1¼, 2½ and 5 inches respectively within working load ranges. Load capacities extend from 43 lbs to 30,550 lbs. The maximum variation in the standard size per ½-inch deflection is 10½% of rated capacity; inversely proportional in short spring and double spring models.

For further information

If you have a pipe suspension problem, you are invited to write: — Grinnell Company, Inc., 282 West Exchange Street, Providence, R. I.

For more data on advertised products, use Readers' Service Cards, last page.



Anaconda Type CP Cable is laid in trench to oil well casing to be protected by cathodic protection. Continental's entire 163-well lease at Ventura, Calif., has been protected with a CP system.

Oil company checks oil well casing corrosion for less than the cost of 3 casing failures—with CP

Anaconda's special Type CP Cable is used throughout.

The corrosion problem at Continental's 163-well lease at Ventura, Calif., was pretty typical: 15 casing failures in 3 years. Cost of repairs—from $22,000 to $61,000 a well—averaging about $125,000 a year for the 3 years that corrosion has been a serious problem.

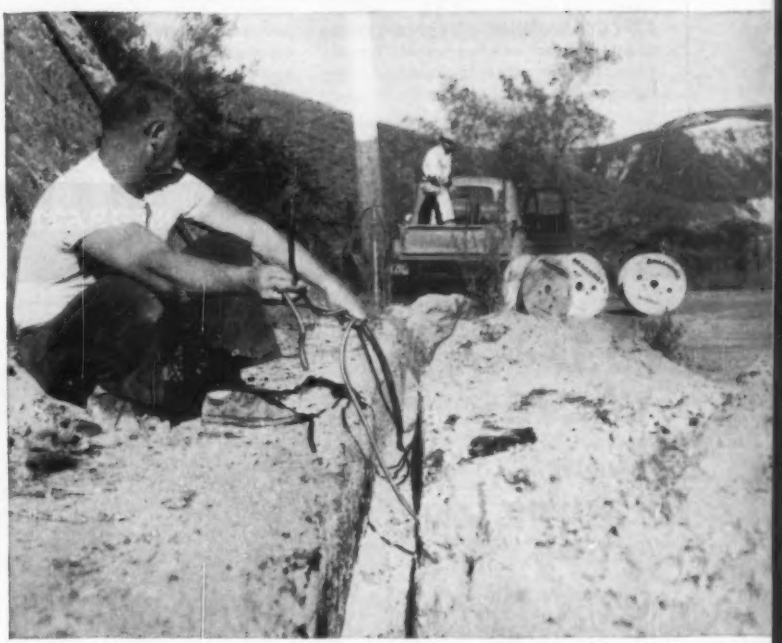
In May, 1954, Continental engineers began investigating cathodic protection to protect oil well casings. One well was set up with cathodic protection — and after six months, a visual examination and an electrical survey showed a definite lessening of corrosion potentials.

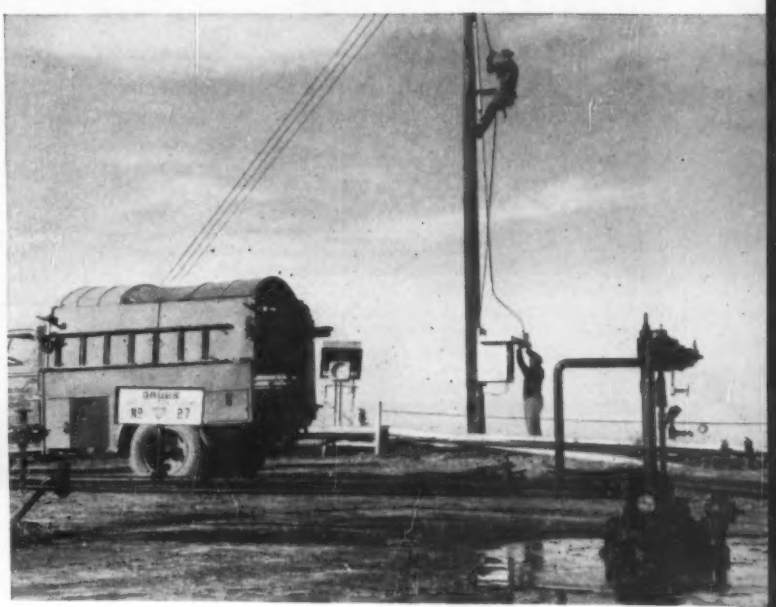
Last year, cathodic protection was expanded to all 163 wells—the first time an entire lease has been protected against corrosion of oil well casings by CP. The cost: $109,000—less than the cost of 3 casing failures.

Heart of the CP system is 49,000 feet of Anaconda's Type CP Cable. Designed *especially* for cathodic protection, Type CP Cable promises longer cable life because of resistance to oil, soil acids, and electroendosmosis.

The Man from Anaconda will be glad to give you more information on cathodic protection for oil well casings and other metal products—as well as complete data on Anaconda Type CP Cable. Call or write today: Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y. 57387

SEE THE MAN FROM **ANACONDA®**





(above, right)

Three anodes—3-by-60-inch shafts of graphite—were used for each casing, buried 10 to 15 feet apart and 11 to 30 feet deep. When wells were grouped, the number in the common field was cut. Here, one worker prepares to lower anode in hole while second man holds bag of carbon coke.

(middle, right)

After ditch-digging machine carved out 18-inch trench, Anaconda's special Type CP Cable was buried in the ditch, connecting the rectifier on base of power pole to anode bed and well head. In some nearly vertical areas, cable could not be buried—but Anaconda's tough Densheath* jacket protects it from sun, wind and rain.

(bottom, right)

Final Step — juice from overhead lines was connected to the CP system.

*Reg. U. S. Pat. Off.

for Type CP Cable

nite lessening of corrosion potentials.

SEE THE MAN FROM ANACONDA

DURA PLASTIC *Teflon* packing for chemicals

DURA PLASTIC STYLE 666 F Die-Molded Rings

DURA PLASTIC STYLE 66 F Spiral

A Completely Lubricated TEFLON PACKING

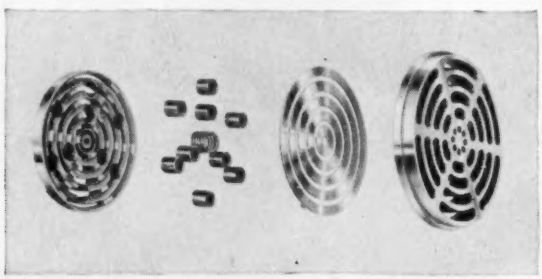
Durametallic's answer to sealing corrosive fluids—DURA PLASTIC *TEFLON* PACKING. It provides long uninterrupted sealing on all liquids except molten alkali metals and some flourine compounds in the higher temperatures. Particularly suitable for packing rods, shafts and stems on processing equipment handling hot caustics, acids, alkalies or organic solvents from -90°F. to 450°F. Supplied in die-molded ring or spiral form.

WRITE FOR DURA PLASTIC TEFLON PACKING BULLETIN NO. 461 PR

The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

VOSS VALVES in your machine mean



LESS MAINTENANCE, FEWER SHUTDOWNS for your compressor. (air, gas, ammonia)

- up to 40% more valve area • minimum pressure loss • higher efficiency
- less power consumption • normal discharge temperature
- quiet, vibration-free • utmost safety • lower operating costs

VOSS VALVES are made to specification, machined from solid stock (not cast) — VALVES and PLATES are of heat-treated alloy or stainless steel; PLATES are machined, not stamped, and ground for precise close-tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS, of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street, New York 54, N. Y.

Men in the Industry . . .

initiating research programs, advising upon technical problems, reviewing current research throughout the nation, recommending new areas of research, and coordinating research programs. NACA objectives are to anticipate the research needs of aviation and to supply the armed forces and industry with basic information for the design and production of aircraft.

Roy E. Nelson has been elected vice president of American Gilsonite Co. In addition to his new duties, Nelson will continue as manager of production in charge of all producing activities of the company, including the new gasoline refinery and coking plant now being built at Gilsonite, Colo.

Nelson

A graduate of Massachusetts Institute of Technology, where he earned the B.S. and M.S. degrees, Nelson joined American Gilsonite in 1949 after serving in various refinery positions with Standard Oil Co. of California.

Garry Owen has been elected a vice president of Arabian American Oil Co. Owen will make his headquarters in Dhahran, Saudi Arabia, and will serve as Aramco's representative in discussions on company matters with the Saudi Arab government.

Owen graduated from the University of California at Berkeley with an A.B. degree in 1924 and was awarded his L.L.B. degree from Harvard Law School in 1927. After practicing law in San Francisco for 12 years, he began his oil career with the Standard Oil Co. of California in 1939, in connection with petroleum concessions in India, Egypt, Bahrain and Saudi Arabia. He transferred to Aramco in 1941. Owen has served as Aramco's representative in Jiddah, Saudi Arabia's diplomatic capital, since 1948. Prior to that he was Aramco's representative in Washington and manager of Aramco's Relations department in Dhahran.

Norman F. Smith, Albert Spaak, and **Ruben Thevenet** have joined the Clifton, N. J. applications laboratories of W. R. Grace & Co.'s Polymer Chemicals division.

Norman F. Smith, formerly with Monsanto Chemical Co. in Canada and Springfield, Mass., has been appointed technical representative of the Marketing department.

Smith, a native of Hamilton, Ontario, was educated at the University of Toronto and McGill University and received a B.S. degree in chemistry in 1948.

Albert Spaak, formerly chief engineer for DeMattia Machine & Tool Co. in Clifton, N. J., and chief engineer for Mastro Plastics, Bronx, N. Y., has been appointed injection molding engineer for the Technical Service department.

Ruben Thevenet will be assigned to the

For more data on advertised products, use Readers' Service Cards, last page.

for Type CF Cable

PDM
ELEVATED STEEL TANKS

1 *of* 8 *duplicate*
pedestal spheres
for
TRUNKLINE GAS COMPANY
Houston, Texas

Efficient, low-cost water storage blends with fine appearance in the eight PDM Pedestal Spheres serving Trunkline Gas Company at various locations. The Pedestal Sphere pictured is at Trunkline's handsome Cypress, Texas station. Each of the water storage units is of 10,000-gallon capacity, 14′6″ in diameter, and 50′ high to overflow. • For full information on the various types and sizes of Pittsburgh-Des Moines Steel Elevated Tanks, write for illustrated catalog.

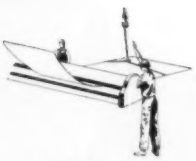
PITTSBURGH • DES MOINES STEEL CO.
Plants at PITTSBURGH, DES MOINES, SANTA CLARA, FRESNO, and CADIZ, SPAIN

Sales Offices at:

PITTSBURGH (25).....3482 Neville Island
NEWARK (2)....263 Industrial Office Bldg.
CHICAGO (3), 1286 First National Bank Bldg.
EL MONTE, CAL.....P.O. Box 2068
DES MOINES (8)..983 Tuttle Street
DALLAS (1)..1287 Praetorian Bldg.
SEATTLE.....590 Lane Street
SANTA CLARA, CAL., 689 Alviso Road

Specialists

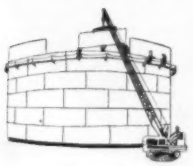
IN TANK AND VESSEL—



Fabrication

Design, Fabrication, Erection, Testing and Repairs

Tanks and vessels—from the first preliminary design to the finished job, completely tested and ready for service—are our exclusive interest. We have no other departments. Every thought is given to producing the very best tank or vessel possible. Next time, let us figure your requirements—whether it's one tank or a hundred-plus tank farm installation.



Erection

ELLERBEE BROTHERS

P. O. BOX 857 PORT ARTHUR, TEXAS X-Ray Testing

MANNING & LEWIS ENGINEERING CO.
28-42 OGDEN ST. NEWARK 4, N.J.
WORKING PRESS:- SHELL TUBES
UNIT NO. JOB NO.

HEAT EXCHANGE and PROCESS EQUIPMENT

THIS NAMEPLATE IS YOUR GUARANTEE OF QUALITY

- Condensers
- Evaporators
- Jacketed Kettles
- Ribbon Mixers
- Agitators
- Reactors
- Pressure Vessels
- Heat Exchangers
- Reboilers

M & L JACKETED REACTORS
(20 gal. and 50 gal. capacities)

Application: Sodium Dispersion Units in Batch Process Operation.
User: Large Chemical Company in Baton Rouge.
Materials: #304 Stainless Steel Shell Carbon Steel Jacket.
Physical Dimensions: 20 gals.—24" O.D.—3' high
50 gals.—30" O.D.—4' high
Working Pressures: Shell 125 P.S.I.
Jacket 50 P.S.I.

Here is another example, among the thousands of case histories in our files, of how Manning & Lewis clearly and logically interpret customers requirements . . . from original concept to finished quality product.

Both the saving in time and cost resulting from our years of engineering experience are two important factors why more and more manufacturers are turning to M & L.

Why not call on us the next time you need equipment. We design and construct to A.S.M.E. or A.P.I. code for unfired vessels or we can build to non-code standards.

Please state *all* conditions of service so that we will be able to handle your inquiry promptly and accurately.

Manning & Lewis Engineering Company
DESIGNERS & MANUFACTURERS OF QUALITY HEAT EXCHANGE EQUIPMENT
28-42 OGDEN STREET NEWARK 4, NEW JERSEY
M.L

Men in the Industry . . .

Technical Service department as a plastics extrusion engineer.

Thevenet, a native of Salto, Uruguay, received his B.S. degree in chemical engineering from the University of Uruguay in 1943. He then studied plastics in the United States under a U. S. government fellowship. For three years he was with General Electric, S.A. in Montevideo, Uruguay, and then was with General Electric's Plastics division in Pittsfield, Mass., prior to joining the Dictaphone Corp. in 1950.

Myron R. Cothern has been appointed manager of the Construction and Equipment division of The Texas Co.'s Domestic Sales department. He will be in charge of planning, coordinating, and supervising new construction and modernization work for Texaco sales terminals, bulk plants and service stations in all 48 states. Cothern succeeds **P. J. Milo,** who retired May 1, 1957.

Cothern graduated from the University of Illinois with a B.S. degree in engineering in 1931 and joined Texaco that year as a draftsman in Indianapolis. He was named construction foreman in 1939, construction engineer in 1940, and assistant manager (Operations) of the Indianapolis Sales division in 1948.

Charles C. Jarchow, president and a director of American Steel Foundries, has been elected to the board of directors of Universal Oil Products Co. Jarchow was elected at Universal's annual stockholder's meeting held recently in New York.

The new UOP board member attended Northwestern University, and became associated with American Steel Foundries in 1912. He held a number of important positions in the company before he became president in 1949.

—Deaths—

Palmer Hughes, 66, regional sales manager of The M. W. Kellogg Co., New York, died at home in Tulsa. He joined the sales department of M. W. Kellogg in 1928, and has represented the company in Tulsa ever since.

Addison Browne Daily, 95, died in Pittsburgh, Pa. He was chairman of Hiawatha Oil and Gas Co. and of Penn-Ohio Company, and a director of Plymouth Oil

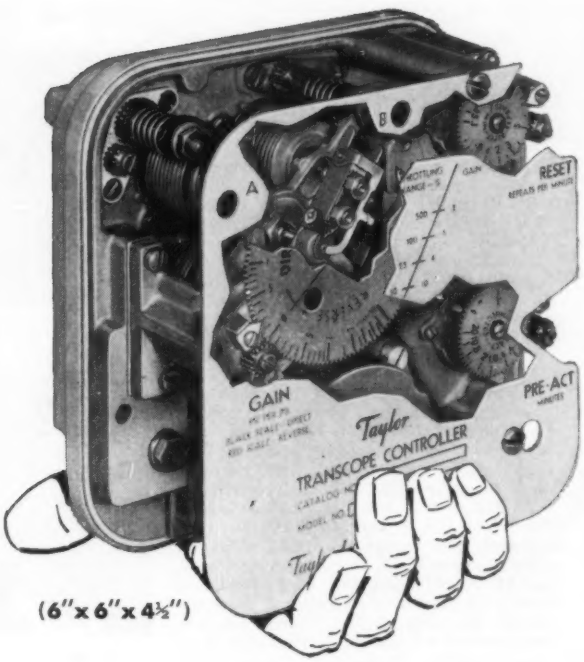
G. Stewart Brown, manager of the Public Relations department of Standard Oil Co. of California, at his home in San Francisco. A veteran newsman and public relations executive, he had in recent years been prominent in petroleum industry affairs, serving as head of the Oil Industry Information Committee in 1955. He had been head of Standard of California's Public Relations Department since 1948.

William Calder, 61, Tulsa, Okla., mechanical superintendent at the D-X Sunray Oil Co. refinery. He was employed at the refinery in 1919 and was assistant master mechanic and master mechanic before he became mechanical superintendent in 1946.

NEW IN PRINCIPLE . . . NEW IN DESIGN . . . NO EQUAL IN PERFORMANCE!

New Taylor TRANSCOPE* Controller

The last word in Pneumatic Process Control



(6"x 6"x 4½")

SUPERIOR PERFORMANCE

1. Especially suited for short spans of measurement . . . ideal for time constants of modern processing . . . outstanding in insensitivity to ambient temperatures.

2. Exceptionally fast and responsive to adjustments —vital on start-ups.

3. Accurate pre-determined mathematical settings made possible by precision manufacture of gain, reset and PRE-ACT* units. Adjustments stay put.

EXCEPTIONAL ADAPTABILITY

1. Adaptable to changes in process requirements . . . complete interchangeability of components so you can convert from simplest to most complex forms of control *in the field* . . . in minutes.

2. Instrument action reversed by merely rotating a dial. Plugs into TRANSET* Indicators and Recorders or locally mounted manifolds.

3. Designed to meet the demand for more compact instruments, it is ideally suited for use in graphic panels and scanning and logging systems.

SIMPLE MAINTENANCE

1. Rugged bellows assembly, keyed in place, moves the dynamically balanced force plate . . . friction-free bending member never needs maintenance.

2. Husky die-cast aluminum assemblies, accessible stainless steel nozzle and baffle, hardened stainless steel reaction members. Dust and moisture-proof case.

3. Ease of alignment—smooth-acting, screw-driver adjustment because of ball bearing construction.

4. Easy to understand . . . easy to get at . . . simplifies maintenance training.

5. Integral cut-off relay is a built-in feature.

*Trade-Mark

The **Transcope Controller** is so compact, so simple, so smooth and responsive to adjustments yet so accessible for every purpose that it really "gets" you. But the "pay-off" doesn't come until you put it on your toughest job. Only then can you realize how contagious enthusiasm can become.

▼ ▼ ▼

Write for **Bulletin 98278.** Taylor Instrument Companies, Rochester, N.Y., and Toronto, Canada.

Taylor Instruments
MEAN
ACCURACY FIRST
VISION · INGENUITY · DEPENDABILITY

For more data on advertised products, use Readers' Service Cards, last page.

What Suppliers Are Doing . . .

Mallory

R. L. Mallory has been promoted by Minneapolis-Honeywell Regulator Co. to manager of the firm's Southwestern sales region, with headquarters in Dallas.

Mallory, 51, had been regional industrial sales manager in Dallas since October, 1952. He succeeds Frederick C. Brandt, who has been named manager of technical services for Honeywell's Commercial division and transferred to the firm's executive offices in Minneapolis. Brandt had been Southwest regional manager in Dallas since 1952.

Mallory joined Honeywell in 1933. After two years as a research engineer in Philadelphia, he was assigned to the firm's sales office in Houston where he served as district sales manager and subsequently as branch sales manager.

Lane

Robert F. Lane has been promoted to executive vice president of Fisher & Porter Co. Lane is presently assistant to the president and a member of the board of directors.

Lane has been with the Hatboro, Pa. instrument manufacturer for 14 years. He is a member of the American Management Association, the Society for the Advancement of Management, the Instrument Society of America, the York Road Industrial Management Club, and the Industrial Relations Association of Philadelphia.

Cook

Roy F. Cook has been appointed assistant controller for the Scientific Instruments division of Beckman Instruments, Inc., Fullerton, Calif. Cook will be in charge of manufacturing accounting for the division. He joins Beckman following a year as controller for the Ward and Harrington Lumber Co., Santa Ana, Calif. Formerly, he was associated with the Townsend Co., New Brighton, Pa., serving as controller of the firm's Cherry Rivet division in Santa Ana.

A graduate in business administration from the University of Toledo, Cook is a member of the National Association of Cost Accountants.

McWhorter

Ray McWhorter has joined **Sinclair Spence** as Fisher Governor Co. sales representative in Venezuela. The territory will now be divided between Spence in the Caracas area, and McWhorter, who will set up an office near Lake Maracaibo.

McWhorter previously spent six years as an instrument engineer in Venezuela with Creole Petroleum Co., and for the last several years has been employed as a sales engineer for control instruments in the middle west.

Anderson

James S. Anderson, formerly general sales manager of the Tubular Products division of The Babcock & Wilcox Co., has been elected a vice president of the company in charge of sales for that division.

A native of Cleveland, Anderson joined B&W in 1941 as a district salesman in the division's New York office. He was named assistant manager of that office the next year and assistant general sales manager of the division in 1948. He was promoted to sales manager in 1953.

Graham

Carl F. Graham has been named director of research and development of Turco Products, Inc.

For the past sixteen years Graham has been with the Wyandotte Chemical Corp. as manager of analytical research. Prior to that, he was laboratory manager of Procter and Gamble's Kansas City plant.

A chemical graduate of Baker University, Graham is active in many technical societies, including the American Society for Testing Materials and the American Chemical Society. He serves on the latter society's Advisory Committee to the U. S. Chemical Corps.

Crum

James D. Crum has been appointed sales engineer assigned to the Baltimore office of Fulton Sylphon division, Robertshaw-Fulton Controls Co.

Formerly Crum was applications engineer in the division's headquarters, Knoxville, Tenn. He joined the organization in 1951 after attending the University of Tennessee.

Crum was in the radar and electronics section of the U. S. Army Signal Corps during World War II. He was discharged in 1946.

McFarland

Richard M. McFarland has been appointed Product Manager—plastics for the FMC Organic Chemicals Division of Food Machinery and Chemical Corp. McFarland, a native of Portland, Me., attended the University of Maine and received his B.S. degree in Chemical Engineering at Rensselaer Polytechnic Institute. He subsequently did graduate work in chemical engineering at the University of Michigan. For the past two years, McFarland has been a member of the Chemical division's Central Development department. He is a member of the American Chemical Society, a past local section chairman of the American Institute of Chemical Engineers, and a member of the Society of the Plastics Industry, the Society of Plastics Engineers and of the Chemical Market Research Association.

Childress

John B. Childress has been promoted by the Frontier Chemical Co., Wichita, Kan., to the post of product manager for industrial chemicals. He assumes charge of marketing, technical service and promotion for Frontier basic chemicals used in industry.

Childress joined Frontier in August, 1955 as a sales representative for the west Texas area, and was later transferred to the North Central states. He previously was associated for eight years with the Chemical Process Co. of Breckenridge, Texas in technical and sales engineering capacities.

King

W. Adrian King has been appointed general sales manager of the Industrial Chemicals division, Olin Mathieson Chemical Corp. This was one of six executive promotions in the division.

King has been manager of the division's automotive products department. He joined the former Mathieson Chemical Corp. in 1953 as manager of hydrocarbon

ANOTHER FIRST FOR EAI
AN ELECTRONIC DIGITAL VOLTMETER

The new electronic Digital Voltmeter, Model 26-26B from Electronic Associates, Inc., enables readouts at speeds formerly thought impossible.

A unique transistorized digital comparator converts analog inputs to the binary coded decimal system in an average time of 0.05 seconds. Delays in readout time are reduced by a factor of 100. Readout accuracy is maintained at 0.01 Volts.

These advances are made possible because of this Digital Voltmeter's completely electronic and transistorized design. The progressive measuring and digitizing circuitry requires no moving parts at all. This results in extreme speeds, noiseless operation, and the greatest reliability.

The Digital Voltmeter is another first in EAI's Program of PACE. For complete details on this, and on any of the Computation Centers maintained by Electronic Associates, Inc. in Princeton, N. J., Los Angeles, California, or Brussels, Belgium, write to: Electronic Associates, Inc., Long Branch, New Jersey, Dept. PR-6

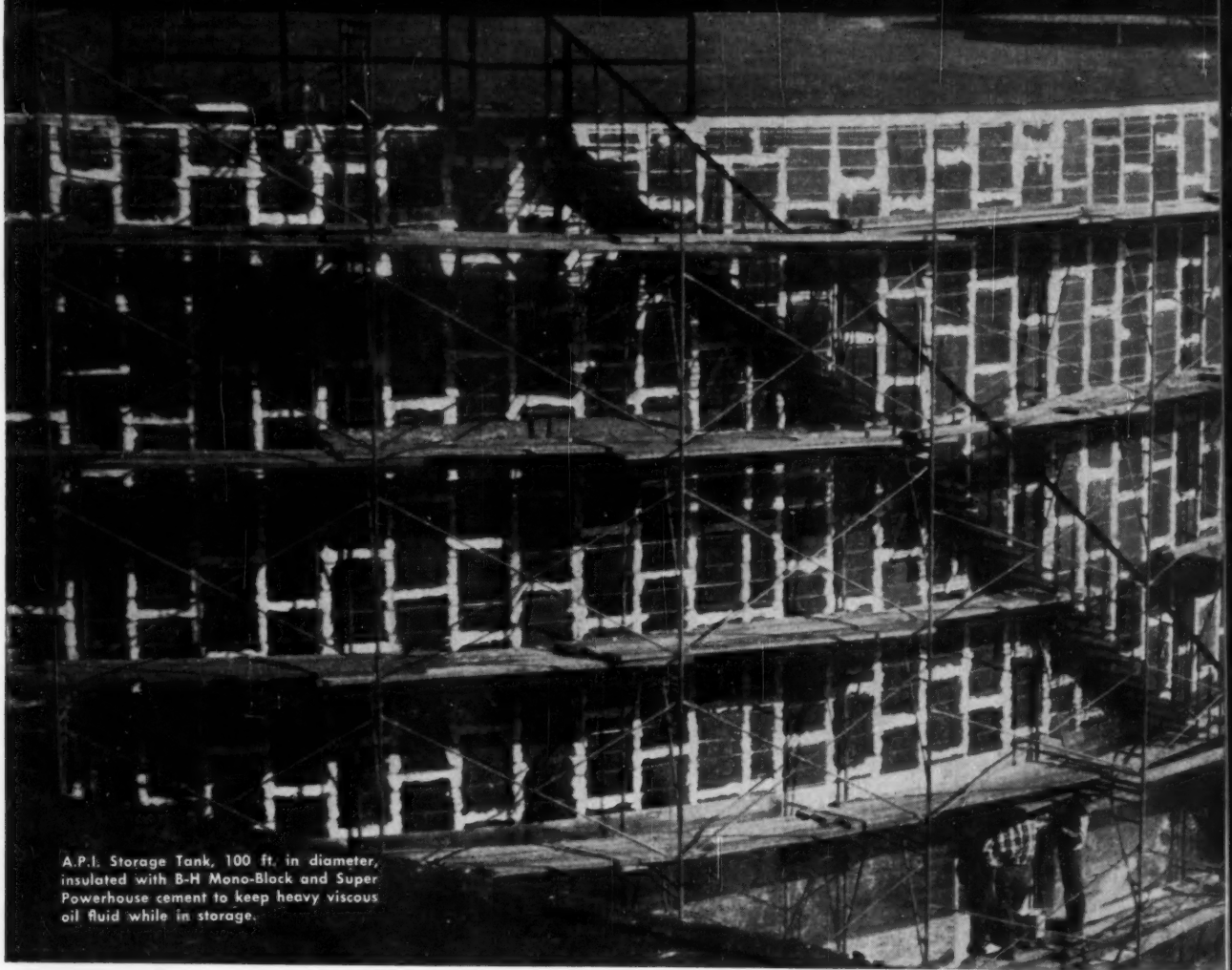
ELECTRONIC ASSOCIATES Incorporated · EAI SETS THE PACE (PRECISION ANALOG COMPUTING EQUIPMENT)

LONG BRANCH • NEW JERSEY

For more data on advertised products, use Readers' Service Cards, last page.

50 Carloads of **BALDWIN-HILL MONO-BLOCK**®

Seal in Heat... at Tidewater Oil Company's Delaware Refinery

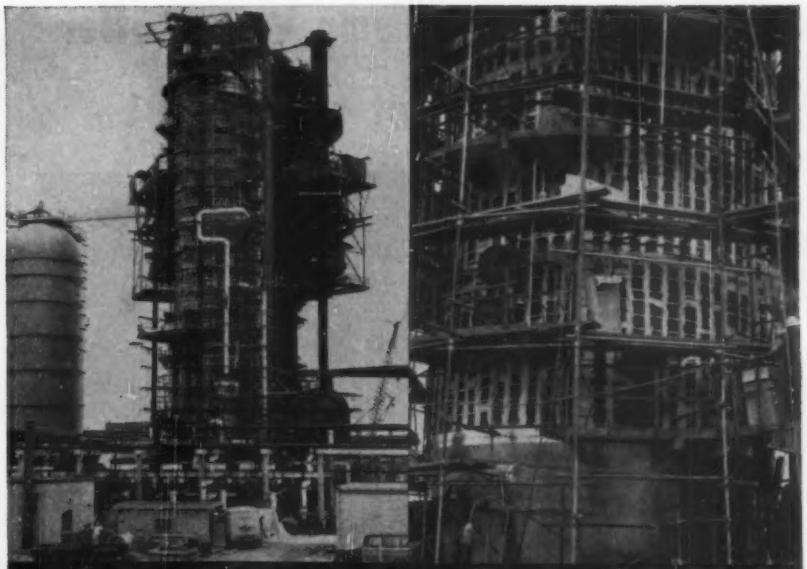


A.P.I. Storage Tank, 100 ft. in diameter, insulated with B-H Mono-Block and Super Powerhouse cement to keep heavy viscous oil fluid while in storage.

Full Temperature Range Covered by One-Block Insulation

For Tidewater's Oil Company's new refinery, C. F. Braun & Co., Engineers and Constructors, standardized on B-H MONO-BLOCK to help prevent costly heat losses and permit better control of operating temperatures. The mammoth job required over 1,000,000 bd. ft. of MONO-BLOCK. This material eliminated the need to purchase and stock special insulating blocks for both low and high temperatures since it is efficient over all temperatures from 75° to 1700° F. Baldwin-Hill's "2 in 1" insulating block reduced inventory control—and its cost—to the minimum.

B-H MONO-BLOCK is felted of long, spun mineral wool fibers and compressed into rigid block with excellent structural strength. It is resilient with an ability to conform to irregular and large curved surfaces without evidence of fracture. MONO-BLOCK is light in weight, extremely simple to handle and apply. It is easily cut with knife or saw to fit odd shapes or smaller areas as required. Stability is assured under severe temperature conditions and it is unaffected by exposure to moisture. . . . In addition, B-H SUPER POWERHOUSE CEMENT was used to point all joints, insuring a tight, unbroken heat barrier, and then applied in a single ½" coat, where required, as an insulating-finishing cement.



Thirty-five stories high, this giant cat cracker is covered with B-H Mono-Block and pointed with B-H Super Powerhouse Cement.

Close-up showing B-H Mono-Block applied to Atmospheric Tower and pointed with B-H Super Powerhouse Cement to seal all joints.

On large vessels, ends of expander straps are fastened to vertical support bars, spaced to allow 1 inch circumferential expansion.

Note how B-H Mono-Block is easily cut and shaped to fit on spherical heads of vessels.

BALDWIN-HILL CO.

Complete line of Industrial Insulations

706 Breunig Ave., Trenton 2, N. J.

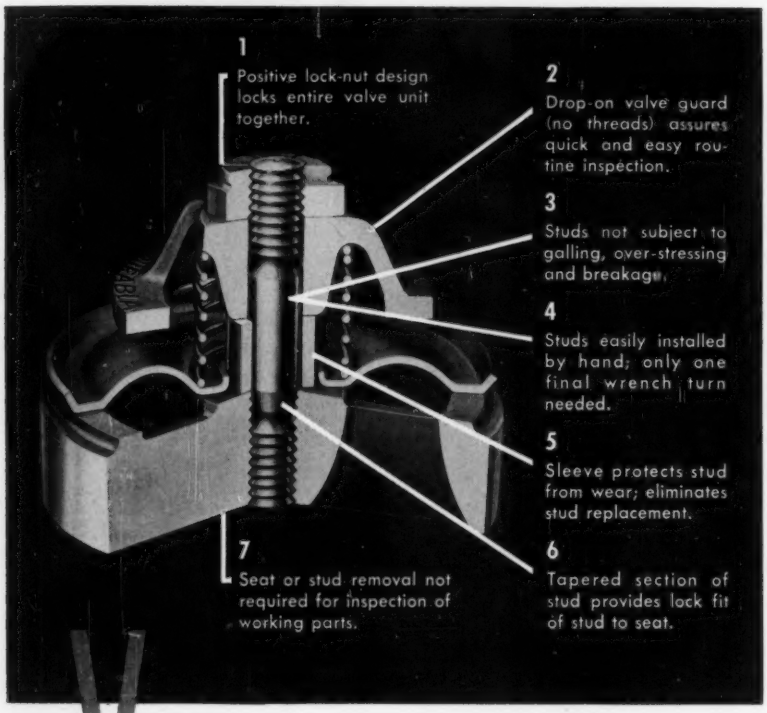
Kalamazoo, Mich. . . . Huntington, Ind. . . . Temple, Texas

See our catalog in Sweet's Plant Engineering File.

For complete report on this installation, staple the keyed corner of this ad to your letterhead and mail.

J-375

Now...DURABLA Pump Valves offer 7 new points of superiority!


1
Positive lock-nut design locks entire valve unit together.
2
Drop-on valve guard (no threads) assures quick and easy routine inspection.
3
Studs not subject to galling, over-stressing and breakage.
4
Studs easily installed by hand; only one final wrench turn needed.
5
Sleeve protects stud from wear; eliminates stud replacement.
6
Tapered section of stud provides lock fit of stud to seat.
7
Seat or stud removal not required for inspection of working parts.

New V-design assures even greater dependability

You want *maximum valve dependability* for your reciprocating pumps . . . and DURABLA gives you just that in the new V-7 unit.

Incorporating seven points of superiority, the new valve features a tapered or V-shaped stud which screws down tight to the seat. This exclusive design anchors the stud, eliminating any possibility of galling, over-stressing or breakage. What's more, the new self-locking nut and drop-on guard assure quick and easy inspection of working parts—without stud or seat removal.

Remember: In the DURABLA Valve, only "point contact" is made by the valve member on the stud sleeve, so it can't bind or hang-up. The open-type guard assures free flow of liquid, prevents clogging.

These stainless-steel valves operate freely under temperature extremes, with corrosives, and in any position. Made in 15 sizes to fit any reciprocating pump, old or new.

Send for *NEW* 8-page booklet PR-67.

Keep your pumps fit with the valves that fit all pumps.

DURABLA®

DM-26

DURABLA MANUFACTURING COMPANY

114 Liberty Street • New York 6, New York

Suppliers . . .

chemical sales and before that was midwestern sales manager of the plastics division of the American Cyanamid Co.

The following appointments were also announced:

James C. Laney succeeds King as manager of the automotive products department. He was formerly national accounts sales manager of the department, which is responsible for sales of the company's anti-freezes and other automotive specialty chemicals.

James F. Newell has been appointed assistant general manager of the Industrial Chemicals division. He was formerly manager of the products department.

Charles C. Hightower succeeds Newell as production head, with responsibility for operation of the division's twelve plants. He has been manager of the Lake Charles, La., plant since 1954.

W. Carlton Moseley, formerly assistant plant manager at Lake Charles, has been named plant manager.

Cecil L. Williamson, who has been manager of the division's administrative services department in Baltimore, has been appointed assistant to the division general manager.

LUKENHEIMER CO. recently honored **Chester C. Isekeit,** vice president and treasurer at a luncheon to commemorate his 45 years of continuous service with the firm.

The luncheon was attended by Lunkenheimer officials and associates of Isekeit. **Paul M. Arnall,** Lunkenheimer president, presented Isekeit with an engraved silver tray and a 45-year service pin.

Isekeit joined Lunkenheimer in 1912 as a stenographer and bookkeeper. He advanced to the positions of auditor and assistant treasurer, and treasurer and controller, before being named vice president and treasurer in 1955.

SCIENTIFIC APPARATUS MAKERS ASSOCIATION has elected **Richard E. Welch** president of the organization at its 39th annual meeting held recently in White Sulphur Springs, W. Va.

Welch is vice president and treasurer, W. M. Welch Manufacturing Co., Chicago. He succeeds **Henry F. Dever,** president, Brown Instruments division, Minneapolis-Honeywell Regulator Co., Philadelphia, who has held the office for the past two years.

Dr. G. A. Downsbrough, president, Boonton Radio Corp., Boonton, N. J., was elected SAMA president pro tempore.

T. M. Mints, president, E. H. Sargent & Co., Chicago, continues as SAMA treasurer.

Newly elected association section chairmen include **A. G. Dixon,** president, International Equipment Co., Boston, laboratory apparatus; and **Erik L. Sjostrom,** president, John E. Sjostrom Co., Philadelphia, laboratory equipment.

Re-elected section chairmen include **Louis L. Vayda,** president, Bacharach Industrial Instrument Co., Pitsburgh, industrial instruments; **L. W. Higgins,** assistant to the president, The Gaertner Scientific Corp., Chicago, optical section; and **R. E. Olson,** president, Taylor Instrument Cos., Rochester, N. Y., recorder-controller section.

Newly elected SAMA directors-at-large are **Henry F. Dever,** president, Brown Instrument division, Minneapolis-Honeywell Regulator Co.; **Ray G. Halvorsen,**

For more data on advertised products, use Readers' Service Cards, last page.

FOAMGLAS®

the cellular, stay-dry insulation

These 4 General Tire tanks, each 9' in diameter and 27' long, operate year 'round at 50°F. and 35 psi to hold vinyl chloride monomer in a liquid state. Accurate, economical temperature-pressure control is easy because the tanks' jackets of 2" FOAMGLAS insure constant, high insulating efficiency. 1000 lin. ft. of supply and refrigeration lines are also protected by 2" FOAMGLAS.

General Tire finds FOAMGLAS stays efficient in tough, outdoor low temperature insulating job

Outdoor low temperature piping and equipment is one of industry's toughest insulating problems. That's why General Tire and Rubber Company picked tough, durable FOAMGLAS to insulate 4 outdoor vinyl chloride tanks, supply and refrigeration lines at their Ashtabula, Ohio plant.

General's past experience with FOAMGLAS at other plants had proved that its inorganic, all-glass composition and sealed cellular structure make it immune to moisture, acid atmospheres, spillage, condensation damage and the other hazards of insulating outdoor equipment. Its insulating value can't vary . . . ever! It's dimensionally stable and completely incombustible, too.

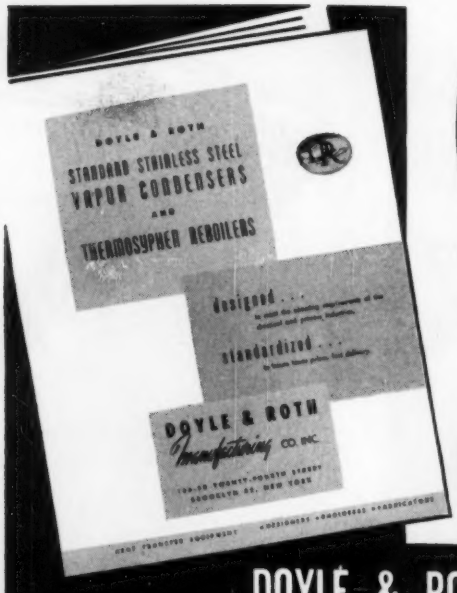
P. J. Wallace, Manager of the Ashtabula plant says: "Even when insulating conditions are toughest, we count on FOAMGLAS for constant efficiency to permit easy, economical control of pipe and equipment operating temperatures. It eliminates frequent, costly insulation replacement and the expensive production shutdowns that result."

What's *your* insulating problem? Tough or easy, you'll solve it best with FOAMGLAS. Prove its unique benefits to yourself! Send today for a free sample and directions for six easy tests to try in your own office. Ask for FOAMGLAS Industrial Insulation Booklet, too. Address . . .

Pittsburgh Corning Corporation
Department Z-67, One Gateway Center
Pittsburgh 22, Pennsylvania
In Canada: 57 Bloor St. W., Toronto, Ontario

PC® **Also manufacturers of PC Glass Blocks**

Application of FOAMGLAS tank jackets was done quickly and at low cost because of the insulation's light weight, strength, rigidity and ease of cutting. FOAMGLAS was banded in place (stainless steel on 9" centers), joints were sealed and a covering spray-coat of fibrated asphalt cutback applied.



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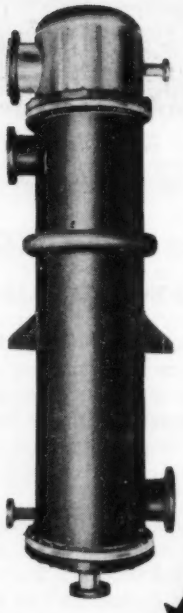
DOYLE & ROTH
VAPOR CONDENSER

STANDARD
STAINLESS STEEL

MODEL— VT

D & R passes on to you the economies accruing from its standardization program. Starting with engineering and following through on construction, economies are substantial. Materials are purchased to rigid specifications and standard components are stocked. ASME standards govern fabricating procedures.

Standardized equipment PAYS . . .
- ★ LOW FIRST COST,
- ★ PROMPT SHIPMENT,
- ★ EASILY REPLACEABLE PARTS *obtainable from stock.*



Send Coupon Today!

DOYLE & ROTH Manufacturing Co., Inc.
140 Twenty-fourth Street, Brooklyn 32, N. Y.

Please send further information
and details on D. & R. Model VT-Vapor Condenser.

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INDIVIDUAL .....
ADDRESS .....
CITY ..... ZONE ..... STATE .....

Suppliers . . .

executive vice president, Hamilton Manufacturing Co.; and **Earl R. Mellen,** president, Weston Electrical Instrument Corp.

Re-elected directors-at-large include **Edward J. Albert,** president, Thwing-Albert Instrument Co.; **Dr. G. A. Downsbrough,** president, Boonton Radio Corp.; and **E. J. Rhein,** sales manager, scientific division, Kimble Glass Co.

PRECISION INSULATION CO., Houston, has been named distributor in the Gulf Coast area for Union Asbestos & Rubber Co., it was announced recently by Ken Dixon, Precision Insulation president.

Dixon

Precision Insulation personnel have considerable background in the insulation field, both industrially and commercially, and form a qualified force in facing insulation problem.

Precision Insulation also holds its engineering personnel available for consultation with engineering and operations personnel of the industrial Gulf Coast.

NATIONAL LEAD CO. has elected **George B. Coale** a vice-president. Coale graduated from the U. S. Naval Academy with the class of 1927. He was employed by The Anaconda Co., before joining National Lead in 1935 as chief engineer of the power plant at the Sayreville, N. J., titanium pigment operation, then as plant mechanical superintendent. In 1940 he was recalled to active duty with the Navy. He served until the end of World War II, attaining the rank of captain.

Returning to National Lead, Coale became chief engineer of the company. In 1949 he was transferred to the Baroid division as assistant general manager. He was named general manager in 1954.

RADIO CORPORATION OF AMERICA has appointed **F. T. Daly** as East Coast and Southeast sales representative for RCA microwave equipment and systems. Daly, formerly marketing and sales analyst for microwave equipment at the department's Camden, N. J. homeoffice, succeeds **L. R. Vincent,** who recently was appointed to a sales post with RCA's West Coast Electronic Products department, Los Angeles.

F. H. Long will succeed Daly as microwave marketing and sales analyst.

Daly has had ten years of engineering and sales experience with the RCA Service Co. and the RCA Communications Products department. He attended Northeastern University, Boston, where he majored in electrical and electronic engineering.

Long, who joined RCA in 1947, has been for the past four years a branch manager in Lancaster, Pa., for the RCA Service Co. He attended both the University of California and New York University, and is a native of South Langhorne, Pa.

TEXAS INSTRUMENTS, INC., has appointed **Don MacIver** as public relations manager. A former newspaperman, MacIver joins TI from the Missouri-Kansas-Texas Rail-

For more data on advertised products, use Readers' Service Cards, last page.

WOLVERINE TRUFIN® BOOSTS ASPHALT HEATER EFFICIENCY

Finned Tube Exchangers on Stream Three Years

BY ERNEST DODD

Until recently in processing work, such heat transfer applications as heating asphalt, crude oil and other heavy residuum materials have been regarded as "tough, dirty jobs."

However, a new day has dawned. Now, thanks to Wolverine Trufin—the integral finned condenser tube—you can heat viscous materials as easily and with as good results as many clean service materials.

As proof of this, consider the performance of two shell and tube U-bend heat exchangers which are used by a Pennsylvania company to heat asphalt, as it moves through transportation lines from the processing plant to storage or distribution.

The exchangers operate with steam on the tube side and asphalt on the shell side. Each is tubed with 112 lengths of Trufin Type S/T, electric-welded steel tube in prefabricated U-bend form. Each has a total surface area of 1600 square feet.

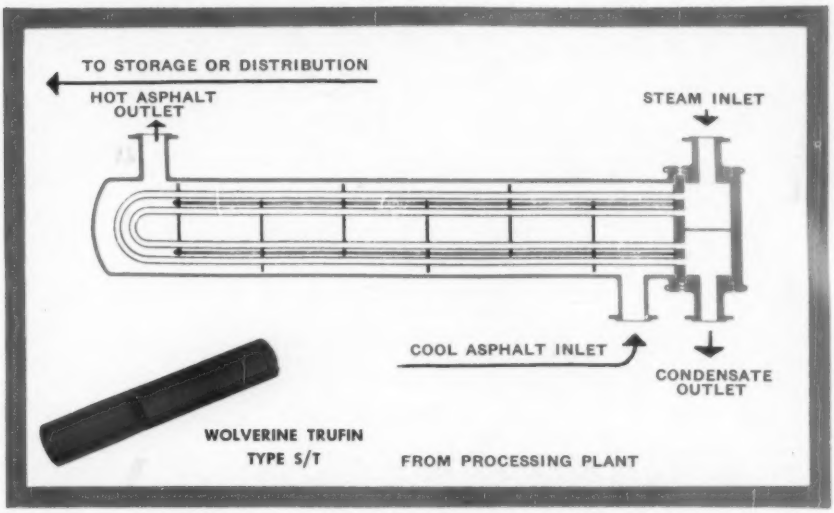
These two units have been continuously on stream for three years and are still going strong. During this time they have not required cleaning or retubing.

Performance such as this, however, is no longer regarded as unusual—when heat exchangers or condensers are tubed with Wolverine Trufin Type S/T condenser tubes.

Through actual on-the-job use, plus extensive pilot plant research and exhaustive laboratory testing, engineers are proving that integral finned Wolverine Trufin resists fouling for longer periods than does prime surface tube.

In addition to increasing on stream time, Trufin also boosts heat transfer capacity because its extended surface extracts more BTU's per foot of tube. As a result, units tubed with Trufin require fewer tubes and smaller shells to obtain equivalent heat duty. The savings in material, labor and construction time are substantial.

For example, the asphalt heaters described in this article, require 116 lengths of Trufin enclosed in 17¼" I.D. shells to obtain individual heat transfer surface areas of 1600 square feet. If designed around prime surface tube, each unit would have required approximately 234 tubes and shells 25" in diameter.

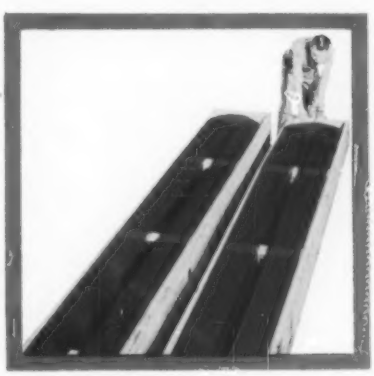


WOLVERINE ONLY DIRECT MILL SOURCE FOR U-BEND CONDENSER TUBES

Through the use of prefabricated Wolverine U-bends in the asphalt heaters described on this page, the engineers concerned realized substantial savings in time, materials and labor.

As the industry's only direct mill source, Wolverine prefabricates U-bends to customer specifications. The tubes are then shipped in expendable type pallets in the exact order of their installation—ready for direct insertion into the unit.

One tube sheet is eliminated and floating head problems are reduced. Rolling in operations are cut in half. Wolverine U-bend tubes also eliminate the shipping and handling problems present when requirements call for condenser tubes over 30′ long.



Wolverine prime surface U-bend tubes are available in a wide range of sizes and alloys in copper and aluminum. Capacity-boosting Trufin U-bends are available in copper, copper-base alloys, aluminum, electric-welded and seamless steel.

SEND FOR FREE BOOK

Because of the nature of its contents Wolverine's Condenser Tube Catalog can serve as a worthwhile addition to engineering reference files. Besides descriptions of Wolverine's complete condenser tube line this catalog contains valuable information on alloys, corrosion, finned tube and its applications and many other subjects of direct interest to those engaged in heat transfer work. Send for your FREE copy today.

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FOREST INDUSTRIES DIVISION
GOODMAN LUMBER COMPANY
CALUMET & HECLA OF CANADA LIMITED
CANADA VULCANIZER AND EQUIPMENT COMPANY LIMITED

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Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA.
SALES OFFICES IN PRINCIPAL CITIES.

EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK

Buy | BOTH TYPES OF CONDENSER TUBE FROM WOLVERINE

To meet the heat transfer needs of the refining and processing industries, Wolverine Tube manufactures condenser tubing in both integrally finned and prime surface form. Each type is the product of Wolverine Tubemanship—is backed by Wolverine's years of tubing experience, constant research, sound engineering and rigid quality control.

FINNED CONDENSER TUBE

Wolverine Trufin® Type S/T was designed specifically for shell and tube installations. This integrally finned condenser tube steps up heat transfer performance because its extended surface extracts more BTU'S per foot of tube.

Type S/T is available in the following alloys:

- Copper
- 70-30 Cupro-Nickel
- 90-10 Cupro-Nickel
- 85-15 Red Brass
- Admiralty
- Electric-welded Steel
- Seamless Steel
- Aluminum Brass

SIZE RANGE:

Specified O.D.

1/2″ • 5/8″ • 3/4″ • 7/8″ • 1″

PRIME SURFACE TUBE

For those heat transfer applications where integrally finned tube is not applicable, Wolverine recommends its prime surface condenser tube. This tubing is rigidly quality controlled to insure maximum performance under the toughest of operating conditions.

Wolverine Prime Surface tube is available in the following alloys:

- Inhibited Admiralty
- Copper
- Cupro-Nickel 10, 20, 30%
- Aluminum Brass
- Red Brass
- Muntz Metal
- Aluminum

SIZE RANGE:

Outside Diameter	Wall Thickness
5/8″ O.D. to 2″ O.D. Inclusive	.049 to .083
	.049 to .134

FIELD ENGINEERING SERVICE

For the convenience of its customers Wolverine maintains its Field Engineering Service—a staff of highly trained tubing technicians. These heat transfer and tubing specialists are trained to come up with the right solutions to problems in design, corrosion alloys, etc. Their services are yours without obligation—can help assure you of complete tubing satisfaction.

Wolverine Trufin is available in Canada through the Unifin Tube Company, London, Ontario.

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES.

•

EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK

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1437 CENTRAL AVE., DETROIT 9, MICH.

Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

road where he was assistant director of public relations for three and one-half years. He previously served 16 years on **The Dallas Morning News** staff, 10 years as business and financial editor.

MacIver is a native of Superior, Wis. He worked on various newspapers in the Middle West and East while attending school and was managing editor of a daily paper in Minnesota before moving to Dallas in 1937. He moved to St. Louis, Mo., in 1953 to accept his position with the M-K-T.

With the appointment of MacIver, TI establishes for the first time a separate department for public relations. Prior to this time, these activities have been handled by merchandising manager **Clark W. Fishel,** in addition to his other duties.

DAMES & MOORE, soil mechanics engineers, has made **Charles Nichols,** formerly chief engineer, an associate in the firm, it was announced recently by **Vernon A. Smoots.** Also announced was that **Malcolm D. Horton,** who has been serving as a staff engineer in the Los Angeles area, has been promoted to chief engineer.

Nichols

According to Smoots, these changes will enable the firm to keep pace with the rapidly growing pace for soil mechanics engineering in the Los Angeles area.

SELAS CORP. OF AMERICA, Dresher, Pa., has announced an expansion of the firm's sales activities, with the formation of an Export division.

The immediate objective of the division is to service the company's recently created European division, situated in Geneva, Switzerland, and to act as liaison between this wholly-owned subsidiary and the main headquarters in Dresher.

Heading the new Export division is **James S. Shute,** previously assistant to the manager of Selas' Combustion Equipment division. Shute has been associated with Selas since 1940 and has served in various design and engineering capacities. He is a graduate of Drexel Institute of Technology, Philadelphia, and is a registered professional engineer in Pennsylvania.

ELLIOTT CO. has appointed **Charles L. Hoebel** district manager of the New York office. A graduate in mechanical engineering from Worcester Polytechnic Institute, Hoebel joined the Elliott Co. New York office as a field engineer in 1952. During World War II, he served with the Navy department and as a lieutenant in the Navy.

H. K. PORTER CO., INC., has appointed **E. M. Richardson** to the newly created post of general sales manager, Refractories division.

Until recently, Richardson was a management consultant in Philadelphia. Previously he was general sales manager for Nice Ball Bearing Co., Philadelphia, Penn.

Richardson attended the University of Pennsylvania, and is a veteran of four years service in World War II, where he served with the U. S. Air Corps.

Suppliers . . .

Lilygren

Fenn

CARRIER CORP. vice president and general manager of the Machinery and Systers division **George Lilygren,** has been placed in charge of the newly-formed Corporate Development division. Lilygren will be responsible for Carrier's integration and acquisition program.

Charles V. Fenn, vice president and assistant general manager of the Machinery and Systems division, has been named general manager to succeed Lilygren.

Lilygren joined Carrier in 1947 as comptroller after many years in the automobile industry. He was elected a vice president the following year.

In March 1951, Lilygren served as an assistant to the director of program and requirements in the Defense Production Administration in Washington, D. C. He returned to Carrier late that year as assistant to the president.

In 1953 he was appointed to the top

Eliminate the high cost of replacements

with CPS cathodic protection

Like pipe lines, the payout period for an investment in cathodic protection for refinery and plant underground systems is usually from about six months to one year, if the protection system is properly designed and installed. Improper design may result in longer payout or actual damage due to interference. Cathodic Protection Service surveyed, designed, installed and checked out a cathodic protection system costing some $200,000. This assured protection of the underground piping, lead-sheathed cable and tank bottoms in this Gulf Coast refinery.

Whether your needs include a complete CPS Package — preliminary survey, design, installation and check out — or the materials alone you can rely on Cathodic Protection Service for the best in service and products.

cathodic protection service

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Maloney Insulating Materials
Fisher M-Scope Pipe and Cable Locators
Agra Instruments
Collins Instruments
Vibroground Resistivity Meters
Holloway Shunts
Scotchrap Plastic Tape

Everything in the cathodic protection field . . . from an insulating washer to a turnkey contract.

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

post in the Machinery and Systems division.

Fenn has spent his entire business career with Carrier. Upon graduation from Stevens Institute of Technology in 1929, he joined Carrier's construction department and five years later was named construction manager for the eastern half of the country.

In 1944, Fenn was made manager of Carrier's direct sales operations in the Southeast. Five years later he moved to Syracuse, N. Y., as manager of the direct sales department, which later became a part of the division he now heads. In 1952 he was named a vice president.

OAKITE PRODUCTS, INC. has announced that **John Mackesy,** one of its San Francisco representatives, for the past 16 years, has been selected as the winner of the 1956 David C. Ball Award for Distinguished Oakite Service. The award, established in memory of the founder of the firm, is given annually to the representative who "best carries forward with his customers the highest ideals of Oakite Service."

Mackesy, a native of Dublin, Ireland, has been with Oakite since 1939, covering the San Jose area before moving to San Francisco. He received the award from **John A. Carter,** company president, at Oakite's recent anniversary conference in New York City.

TRIANGLE BRAND
COPPER SULPHATE
the Superior Reagent for "Sweetening"
Sweetening in oil refining and processing demands a superior reagent either in the dry form or in aqueous solutions. Triangle Brand Copper Sulphate is versatile and is effective in partly desulphurizing oil, or removing mercaptans, other sulphur compounds, malodorous and resinous substances from cracked distillates.
Triangle Brand Copper Sulphate, 99% pure, will be your reagent of choice once you use it!
PHELPS DODGE REFINING CORPORATION
NICHOLS
TRIANGLE BRAND
REG U.S. PAT. OFF.
CHEMICALS
NEW YORK N.Y.
PHELPS DODGE REFINING CORPORATION
300 Park Avenue, New York 22, N. Y.
5310 West 66th Street, Chicago 38, Ill.

Feldman

Schwanhausser

WORTHINGTON CORP. board of directors has elected **Walther H. Feldmann** president, succeeding **Edwin J. Schwanhausser,** who becomes vice-chairman. **Hobart C. Ramsey** continues as chairman and chief executive officer.

Feldmann was first associated with Worthington in 1944 as president and general manager of Electric Machinery Manufacturing Co., which became a part of Worthington in that year. He had been with Electric Machinery since 1922, and had served as general sales manager and vice president in charge of sales. He was elected vice president of Worthington in charge of sales in 1950, and executive vice president in 1955. He has been a member of the board of directors since last September.

Schwanhausser joined Worthington in 1915 in the engineering department of the Harrison, N. J. works. Prior to becoming president, he was elected vice president in 1939, vice president in charge of sales in 1945, and executive vice president in 1949. He has been a member of the board of directors since 1942.

HILLS-McCANNA CO., Chicago, has appointed The Laidlaw Co., 1606 N. Illinois Street, Indianapolis, as exclusive stocking distributor for Hills-McCanna valves and replacement parts in Indiana and Eastern Illinois.

THE A. O. SMITH CORP. has announced a reorganization of its Pacific Coast works. **W. L. France,** general manager of the company's operation in Los Angeles announced the formation of a Meter and Service Station Pump division. It has been placed under the management of Harry G. Smith, formerly executive vice president of the Ohio Injector Co., Wadsworth, Ohio.

Smith, widely known for many years in the petroleum meter field, returns to A. O. Smith after an absence of seven years. Prior to that, he was with the Smith Meter Co., then a wholly owned subsidiary of A. O. Smith.

SOUTHERN TOOL DISTRIBUTING CO., Atlanta, Ga., has been recently appointed an authorized cutting tool distributor by General Electric's Metallurgical Products department, Detroit.

CHICAGO BRIDGE & IRON CO. has promoted **I. E. Boberg,** from chief engineer to vice president of the company. Also **Leo J. Marcoux,** controller, has been elected secretary.

Boberg, who is a graduate of the University of Illinois, joined CB&I in 1924. In 1927 he left to work in the consulting field. In 1935 he returned to the company's Chicago Engineering department, where he served until 1941 as assistant to the chief engineer. He has been chief engineer of CB&I since 1945.

Marcoux joined CB&I in 1923. During

For more data on advertised products, use Readers' Service Cards, last page.

Stainless transfer lines last three times as long as carbon steel —*still no sign of corrosion*

The picture shows the Pure Oil Company Smith's Bluff Refinery at Nederland, Texas. The two-stage distillation unit contains both atmospheric and vacuum furnaces, and both of them used to have carbon steel transfer lines. They lasted an average of 1½ years.

About four years ago, they replaced the lines with Type 304 Stainless Steel lines, in an effort to lick high temperature sulfur and chloride corrosion. The project was a complete success because, after four years, there is still *no* sign of corrosion.

In high-production, modern refineries like this one, there are very few investments that will pay off as well as Stainless Steel. Naturally, you get your greatest return when you design with Stainless from the very beginning. And you get the assurance of service-tested quality when you design with *USS* Stainless Steel.

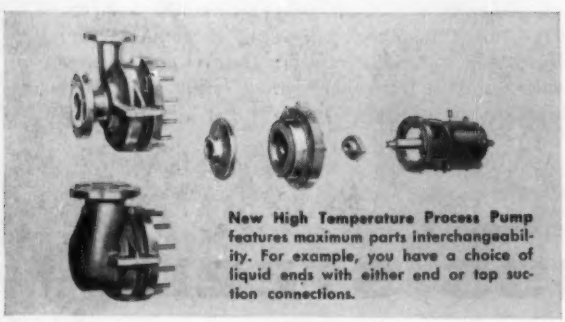
UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS • PIPE • TUBES • WIRE • SPECIAL SECTIONS

UNITED STATES STEEL

NOW! A LOWER COST ALL-



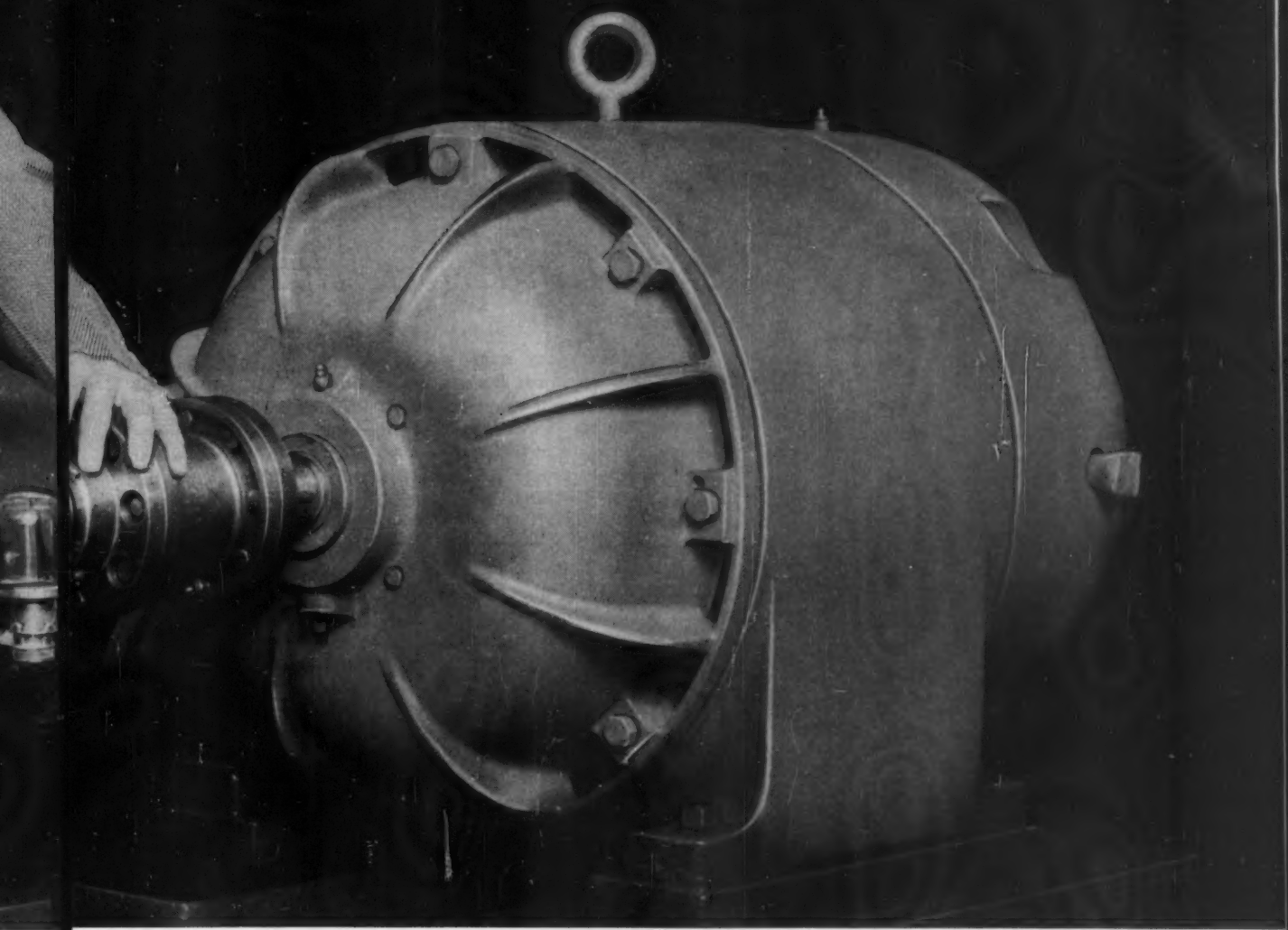
New High Temperature Process Pump features maximum parts interchangeability. For example, you have a choice of liquid ends with either end or top suction connections.

Here is the latest product of Worthington research – the new HN line of centrifugal pumps. Designed especially for process industry pumping problems, these heavy-duty pumps can meet all operating conditions up to 850 F and 600 psig.

Versatility. The HN line allows you to choose exactly the right pump. There are three models available: the HN with end suction; the HNT with top suction; and the HNC with integral seal. You have a choice of stock materials of construction – and for those severe corrosive conditions special alloys can be provided. Stuffing boxes are suitable for packing or mechanical seals in full compliance with API specifications.

The integral seal pump gives you all the advantages

There's always **PUMP NEWS** from Worthington



SERVICE PROCESS PUMP

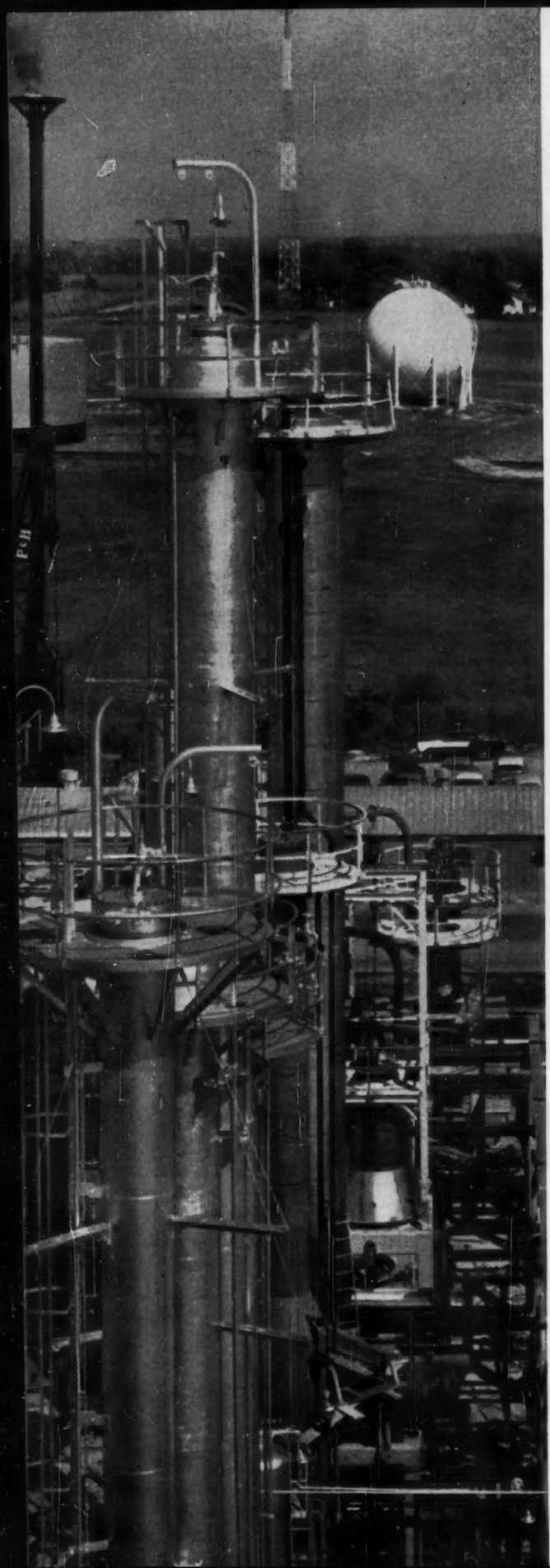
of mechanical seal operation and features a totally enclosed seal housing for safe disposal of leakage vapors. Only one size seal is required for all pumps.

The "built-in" versatility of the HN line gives you application flexibility that takes care of changing conditions and cuts operating costs.

Interchangeability. The entire HN line is built to the same basic design, thereby simplifying maintenance procedure and offering maximum parts interchangeability. Only two bearing assemblies are required for thirteen sizes of pumps. Pumps on the same bearing assembly use identical bearings, shafts, sleeves, and packing or mechanical seals. And end or top suction casings are completely interchangeable.

For more information about the versatile new HN pump, or other units in Worthington's complete line of centrifugal pumps, get in touch with your nearest Worthington District Office. Or write to Section C-74, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Brantford, Ont.

WORTHINGTON



This SWECO-built refinery addition helped an Indiana plant pull from behind to a front position in the race to upgrade gasoline.

High Octane Package Handled with Care

Like many refineries, the Mt. Vernon plant of the Indiana Farm Bureau Association was caught with its rating down when the latest high octane race started. That was before SWECO wrapped up a $1,500,000 refinery package that included a 3,000 BPSD platformer, a 2,100 BPSD unifiner, and a new steam generating plant with an hourly capacity of 120,000 lb. of high-pressure steam.

Off and running

The platformer-unifiner team went on stream in November, 1956, and has been in continuous operation ever since. This combination unit, built under license from Universal Oil Products Company, makes Mt. Vernon a front runner in today's race to upgrade gasoline.

In planning the steam generating plant, SWECO engineers decided to save time by specifying the equipment and letting bids for fabrication. But outsiders couldn't meet the cost estimates or contract, so SWECO built the pressure vessels in its Los Angeles plant. They were delivered three days ahead of schedule.

Problems in stride

Heavy spring washouts and a tight budget were just some of the problems the SWECO engineering and construction crews took in stride. Designing and building moderate-size refinery installations is their specialty.

This is the kind of service, the extra service SWECO clients in the process industries expect. Large or small, at home or abroad, it's the only kind they get . . . in the *engineering and construction* of refineries (SWECO *is licensed to build plants for practically all major refining processes)*, chemical plants and ore beneficiating mills . . . in the design and manufacture of *process equipment* such as heat exchangers, steam jet ejectors and distillation columns . . . in a full line of *vibrating screen separators.*

Write today for our new brochure on how SWECO products and services can help meet your processing needs. Ask for brochure E-2-333.

SWECO

Southwestern Engineering Company

4800 Santa Fe Ave., Los Angeles 58, Calif.

Suppliers . . .

World War II he was in charge of the financial and accounting department of the company's Shipyard division. In 1946 he was elected controller of the company.

•

THE BABCOCK & WILCOX CO. board of directors has elected **M. Nielsen** president. For the past two years executive vice president of the company, Neilsen succeeds **Alfred Iddles,** who is retiring after serving as president since 1948.

Nielsen

Nielsen joined B & W in 1924 as a construction worker in Chicago. In five years he rose to district inspector, and in 1937 was made district erector in charge of the Cincinnati district.

Moving into the marine area of boiler work, Nielsen was promoted to superintendent of marine erection in 1939. In 1947, he moved to production superintendent of the firm's plant in Barberton, Ohio.

Appointed an executive assistant in 1950, Nielsen moved to B&W's New York offices to take charge of its contract department, and in 1952, he was elected assistant vice president of the Boiler division's manufacturing department.

Nielsen rose to vice president in 1953, and assumed charge of all Boiler division manuafcturing. Reelected in 1954, he was made head of the entire division, and at the same time became a member of the board of directors. The next year, he was elected excutive vice president.

THE FOXBORO CO. will start construction in July on a new addition to the company's instrument manufacturing plant at Foxboro, Mass.

The new structure, adjoining the present instrument assembly building, will expand production capacity 50 percent, enabling the firm to meet industry's increased demand.

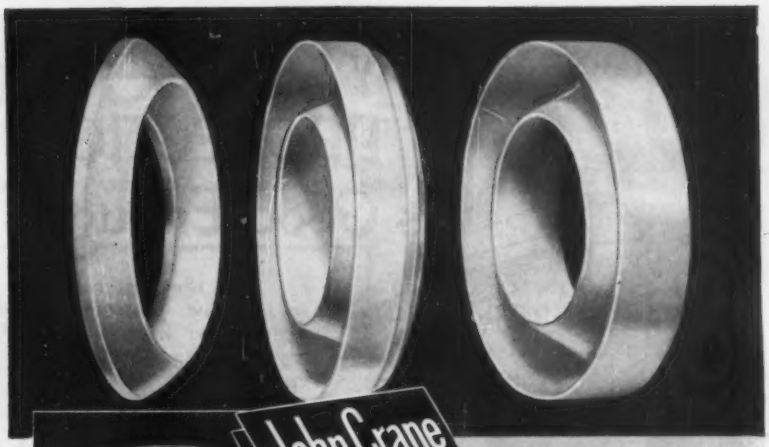
Of one story construction, the new factory building will be 475 feet by 250 feet and will house a receiving department and all machining and finishing operations. Fronting this area will be a two story office building, 300 feet by 50 feet, for administrative and office personnel. Storage

Be Sure To Check This Month's Classified Section in REFINER

Need Engineers - Technical Personnel? Try a Classified Ad in Petroleum REFINER.

QUICK! ECONOMICAL! RESULTFUL!

Help Wanted! Classified Ads in Petroleum REFINER get the job done.



John Crane

CHEMLON *

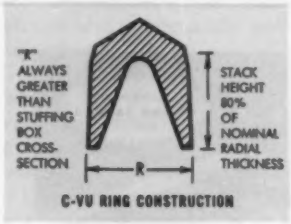
C-V RINGS

ARE INDUSTRY'S MOST UNIVERSAL PACKING . . .

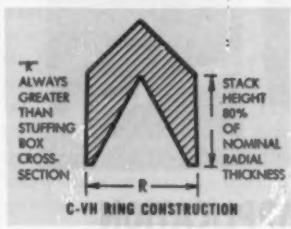
Countless successful applications of C-V Rings under the most severe service conditions have made this the closest approach to a universal packing.

It will effectively handle all industrial acids, alkalis, solvents, organic and hydraulic fluids . . . temperatures from −120°F. to +500°F. . . . is equally suited to valves, pumps, mixers, hydraulic cylinders and like equipment.

"John Crane" C-V Rings have extremely low coefficient of friction. "Breakout" friction is only slightly higher than running friction.



C-VU RING CONSTRUCTION



C-VH RING CONSTRUCTION

TWO STYLES ARE AVAILABLE:

C-VU RINGS ***for low pressure service*** —such as control and regulator valves handling gases and fluids, where it is necessary to have a very sensitive and resilient type packing.

C-VH RINGS ***for high pressure service*** —for use in pumps, hydraulic cylinders and like services at pressures ranging to 500 psi. and over. These rings are constructed with a heavy wall heel to withstand pressure requirements. They are designed to provide voids between rings, so that as the Teflon expands due to heat, this take-up room minimizes any excess friction in the stuffing box.

"John Crane" C-V Rings are available in full line of standard sizes and male and female adaptors. Sizes can be molded to stuffing box specifications.

Request Bulletin P-325.

*"John Crane" C-V Rings are made from Chemlon—*the best in DuPont Teflon.*

Crane Packing Co., 6420 Oakton St., Morton Grove, Ill. (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

CRANE PACKING COMPANY

For more data on advertised products, use Readers' Service Cards, last page.

Quoth Sir Galvaknight: **Only Complete PROTECTION is Good Enough**

And the best *complete* anti-rust protection for iron and steel is hot-dip galvanizing. The hot-dip process seals out corrosion on *all* surfaces, as no other protective coating can. Armor-plate your iron and steel with hot-dip galvanizing by the Southwest's largest commercial galvanizers, the Nowery J. Smith Company!

Nowery J. Smith COMPANY

Commercial Galvanizing

one of the SMITH INDUSTRIES

8000 Hempstead Hwy. UNderwood 9-1425
P. O. Box 7398 Houston 8, Texas

A PACKING FOR EVERY APPLICATION

LOWEST COMMERCIAL H.E.T.P. ..... STEDMAN
LOWEST PRESSURE DROP ..... GOODLOE
HIGHEST CAPACITY ..... PANAPAK

Bulletins and Additional Information on Request

PACKED COLUMN CORP.

PACKED COLUMN CORPORATION
30 Church Street, New York 7, N. Y.

Suppliers . . .

facilities will be provided by a new warehouse, 60 by 200 feet, adjoining the factory addition. With the 175,000 square feet added by this new construction, the firm will have 475,000 square feet of manufacturing space.

Completion of the addition is scheduled for early summer of 1958.

UNITED STATES RUBBER CO. has appointed **William J. Reddington** St. Louis district sales manager for the mechanical goods division. Reddington replaces **Hugh Reynolds**, who retired February 1 after 30 years with the rubber company. Reynolds had been St. Louis district sales manager since 1944.

Reddington, a native of Passaic, N. J., has been with U. S. Rubber since 1933, and a member of its mechanical goods sales staff since 1937.

Christensen

Reed

THE MARLEY CO., Kansas City, Mo., has created a new sales executive position, that of director of sales and advertising, which will be filled by **Lyle A. Christensen**, a company vice president and for 11 years general sales manager. In his new capacity, Christensen will have charge of the company's marketing program. Christensen joined The Marley Co. in its New York City sales office in 1942 and was transferred to the home office in 1946.

Bateman

Succeeding him as general sales manager is **F. B. (Frosty) Reed** who has been elected a vice-president. Since joining the company 16 years ago, Reed has filled several positions in the Marley sales division, the most recent of which was that of assistant general sales manager. He now supervises Marley sales through its branch offices and sales representatives.

John H. Bateman, technical assistant to

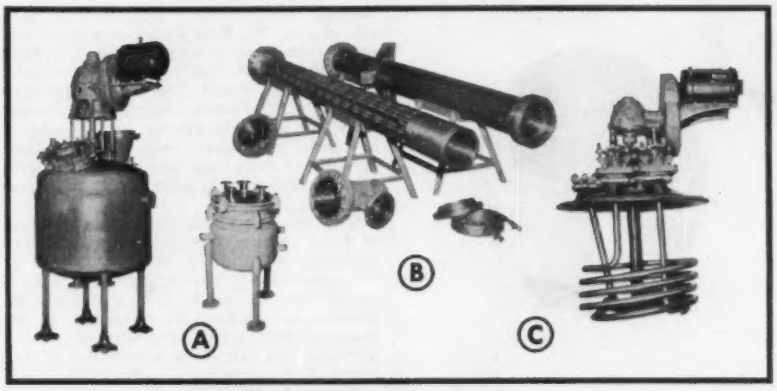
Free to PETROLEUM REFINER Subscribers

Write for free booklet on preparation of articles for PETROLEUM REFINER, the technical press generally, as well as papers for technical meetings. Use Reader's Service green cards in the back of this issue. Write on the card "Free Author's Booklet," fill in name, address and mail. No charge, no obligation.

Corrosioneering News

Quick facts about the services and equipment available to help you reduce corrosion and processing costs.

Published by The Pfaudler Co., Rochester, N.Y., U.S.A.



A. Pfaudler titanium reaction kettles for high-temperature processing.
B. Pfaudler packed floating head titanium heat exchanger.
C. Pfaudler titanium loop coil for use in titanium reactor.

When should you use titanium process equipment?

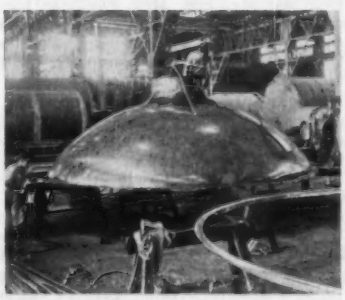
Titanium, a relatively new material of construction, shows great promise in reducing corrosion costs under severe chemical conditions.

As corrosioneers, Pfaudler has studied its characteristics, developed welding techniques, designed and built quite a range of titanium process equipment. Some are shown above and others are being fabricated now.

Because production costs of titanium have been greatly decreased, titanium should now be considered as a material of construction wherever it is economically feasible to do so. It has superior resistance to nitric acid solutions at high temperatures, chlorinated organics and inorganic chloride solutions, and shows excellent resistance to mixtures of sulphuric and nitric acids and also to aqua regia.

There are also other materials which provide excellent chemical resistance, among which is Pfaudler glassed steel. Each case should be considered on its own merits.

Our main point is this: When you are up against any kind of a corrosion problem, Pfaudler is ready and anxious to give you the benefit of its 73 years of experience in designing and fabricating equipment that will do the best job at *the lowest over-all service cost*. If titanium is indicated, you can rely on Pfaudler know-how to do just that. Your inquiries are welcomed.



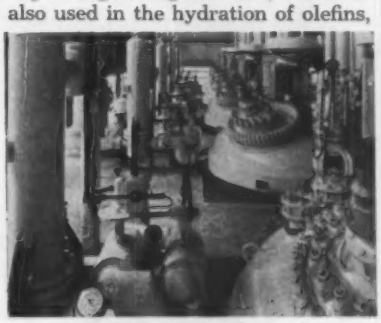
Copper and copper alloy equipment . . . For services involving acid solutions of low oxidizing capacity, copper and copper alloys may be the best answer to your problem. Pfaudler's long experience in building copper vessels and heat exchangers assures you of top-quality engineering and workmanship. You will also find Pfaudler prices competitive. Let us quote on your requirements for equipment of this type.

Glassed steel for the petroleum industry

The petroleum industry, like chemical processing, finds in glassed steel equipment a material of construction which is proving most economical in the battle against corrosion.

Great improvement in the resistivity of Pfaudler glass and its application to many different types of open hearth steel designs, are mainly responsible for this trend. Pfaudler glass, now resistant to all acids (except hydrofluoric) and to alkaline solutions to pH 12 at 212° F., provides about as much flexibility as you can find in any one material of construction.

Used in the form of reactors, columns, settlers, mixers, storage tanks, pipe, fittings and valves, Pfaudler equipment is giving excellent service for reactions involving hydrochloric acid, chlorinated solvents, pesticides, vapor degreasing solvents, etc. It is also used in the hydration of olefins,



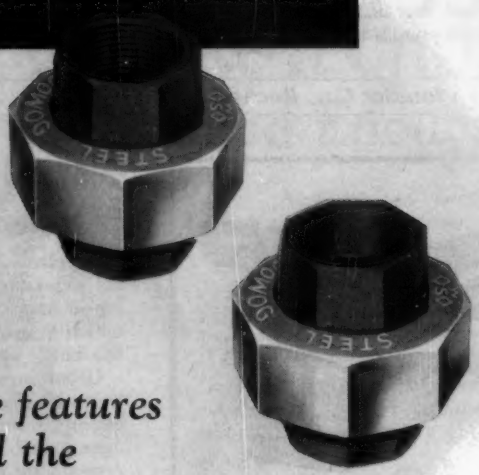
to prevent corrosion by sulphuric acid, in certain phases of producing cumene-derived phenol and by-product acetone in polyester resins and synthetic fibres.

Installations of Pfaudler glassed steel polymerizers are so numerous that standardized designs have been developed. Glassed steel can be cleaned quickly after each run; a build-up of product within the vessel is easily prevented.

In petroleum refining operations, corrosion during crude distillation has been minimized. Glass helps to prevent passage of hydrogen to the steel surface, eliminating atomic hydrogen attack. There are other applications too numerous to include here. May we send you more information?

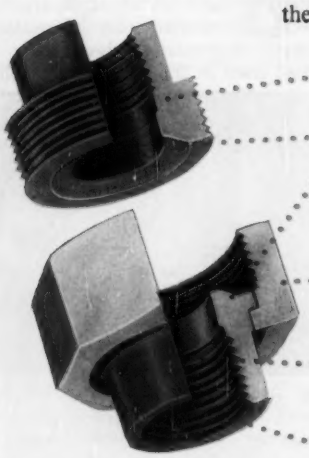
For more data on advertised products, use Readers' Service Cards, last page.

W-S Forged Steel Unions



. . . these features tell the difference . . .

Not all forged steel fittings are alike. Careful design and precision manufacture give W-S Forged Steel Unions these important features that tell the difference:



1. Designed to AAR dimensional specifications.
2. Steel-to-steel seats, with spherical-to-angle mating surfaces. Angle is rolled to extra hardness to resist galling.
3. Cadmium plated nuts for resistance to corrosion and to galling and siezing.
4. End pieces protected against rust by new W-S blue synthetic coating.
5. Octagonal end pieces for better gripping.

W-S Unions are machined from forged steel in accordance with ASTM material specifications A-105, Grade 2. They are available with screw-end and socket-welding end pieces in 3000 lb. class, sizes ⅛" to 3".

For complete information send for Bulletin U-1. Write to W-S Fittings Division, H. K. Porter Company, Inc., P. O. Box 95, Roselle, N. J.

HKP W-S FITTINGS DIVISION
H. K. PORTER COMPANY, INC.

Suppliers . . .

the sales work of the company's present export connections and will develop new connections throughout the world. Bateman was originally with the Marley engineering division and started with the company in 1941.

MEXICO REFRACTORIES CO., Mexico, Mo., has elected **W. Basil Leach** president and has elevated the company's founder, **John B. Arthur,** from the presidency to chairman of the board and chief executive officer. Arthur will continue to consult with the management on policy matters.

Leach, previously vice president and director of sales, has been associated with Mexico Refractories since its formation in 1929.

The Board also announced the election of **C. A. Smith,** vice president and chief engineer, to a newly created position of executive vice president, retaining the responsibility of chief engineer. **Carl H. Bachmann,** production manager of the Mexico, Mo. plant, was elected a vice president; he has been a member of the board of directors since early 1955.

Roger A. Hitchins, vice president and general manager of the company's National Refractories division, and **P. J. Geib,** assistant treasurer, both of the Philadelphia office, became members of the board of directors by vote of the stockholders which increased membership from 7 to 9. Reelected to the board were **John B. Arthur, C. H. Bachmann, L. H. Hosbein, J. H. Kruson, W. Basil Leach, C. A. Smith** and **E. C. Tinsley.**

U. S. GAUGE DIVISION, American Machine and Metals, Inc., Sellersville, Pa., has named **Joseph A. E. Hindman** sales manager.

This announcement follows previous disclosures of personnel and plant changes, which involve the construction of additional manufacturing facilities at the Sellersville site, and shift of **Philip Johnston,** formerly general sales manager, to vice president and general manager. Johnston succeeds **I. N. Becker,** who becomes vice president of operations for American Machine and Metals, Inc.

RHEEM MANUFACTURING CO. has announced that **Edward F. Paquette,** vice president and general manager of the Container division, has been given the Bonelli Award by the unanimous vote of the Rheem executive committee.

The award, a gift of Comm. Francesco Bonelli, president of S.A.F.I.M., of Milan, Italy, provides an all-expense European tour for Mr. and Mrs. Paquette for approximately four weeks. During this time, they will have an extended visit with Comm. Bonelli and his company, the Italian affiliate of Rheem Manufacturing Co.

Joining Rheem in 1945, Paquette has served in positions in manufacturing and management. Prior to his present capacity, he was region manager in charge of Rheem operations based at South Gate, Calif. His earlier Rheem experience included positions as region manager in Seattle, and plant manager in Richmond, Calif. When the Container division was organized as a separate operation early in 1956, Paquette became general manager and vice president.

For more data on advertised products, use Readers' Service Cards, last page.

–Photo courtesy Standard Oil Company (N.J.)

How soon will you be forced to recover stack BTUs?

The constant rise in cost of fuels means simply this: it is becoming more and more uneconomical to dissipate so much of your fuel up the stack. Particularly, since so much of it – nearly one third – can be put *back to work.*

For with modern process equipment, which includes a Ljungstrom Air Preheater, you can save as much as 30% of the fuel burned! That's a *saving of 1½ barrels in every five.*

Heat recovery can also be used to generate higher flame temperatures and increase heat-transfer rates. This makes it possible to *raise through-put as much as 25%.*

LJUNGSTROMS ARE WRITTEN OFF FAST

Ljungstrom has many other advantages. More complete combustion greatly reduces slagging . . . makes possible use of lower grade fuels . . . helps raise product quality. With these added benefits it's not difficult to see why a Ljungstrom is often paid out in less than a year.

For more complete data on what Ljungstrom Air Preheater can do to help you save on production costs . . . and for an analysis of the heat recovery benefits obtainable in fuel burning equipment – call or write the Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

PETROLEUM REFINER Classified Ads

Petroleum Refiner New Classified Rates

RATES: Regular Classified (undisplayed) set in this size type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads,** set in suitably larger type with ruled border, $12.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

* * * * * * * * * * * * * * * * *

HELP WANTED

■ Chemical Engineers Wanted—By a medium sized petroleum refinery located in the Northwest. Two to five years experience in economic forecasts and process analysis with a degree in Chemical Engineering from an accredited engineering school preferred. Salary based on experience, education, and qualifications. Liberal benefit and retirement plans. When making application, please furnish a resume of experience, personal data, activities, and a copy of college transcript. Replies will remain confidential. Box 269-R, PETROLEUM REFINER, Houston, Texas.

IRAQ

Jobs in Iraq, new refinery, family accompanies. Excellent salaries and benefits, three year renewable contract. Age open. Must be U.S. citizen with refinery operating experience. Degree required.

NO U. S. INCOME TAX
OUR FEE PAID

ASST. CHIEF COORDINATOR, lube and asphalt. Minimum 7 yrs. experience, including supervisory. Ch. E. Degree.

ENGINEERING OPENINGS for civil, electrical, project, mechanical, chemical engineers, minimum 3 yrs. experience.

All inquiries confidential. Send resumes of experience to:

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SENIOR REFINERY ESTIMATOR

Here is a one-of-a-kind chance for you and your family to move to a new way of life in sunny, mild northern California.

The requirement is 15 years or more experience estimating refinery, petrochemical plants, process and off-site facilities.

Salary is excellent; benefits include hospitalization and life insurance, retirement, moving allowance; indoor-outdoor living in the San Francisco Bay Area close to all recreation, leading schools and universities. Housing no problem.

Write today—in confidence of course!

KAISER ENGINEERS
1924 Broadway, Oakland 12, California
Division of Henry J. Kaiser Company

HELP WANTED

ENGINEERS DESIGNERS AND DRAFTSMEN

FOR PLANT LAYOUT AND PIPING LAYOUT WORK

Permanent position offering challenging and varied assignments. Full application and appreciation of your training and experience assured because engineering designing and drafting is our business. University and technical night classes encouraged. High starting salaries and regular salary reviews. Housing, cultural and recreational facilities to suit every taste available in Cincinnati. We pay moving costs.

Apply for interview by writing:

Mr. R. L. Parker
Vulcan Engineering Division
Vulcan-Cincinnati, Inc.
120 Sycamore Street
Cincinnati 2, Ohio

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HELP WANTED

CHEMICAL ENGINEER

Chemical Engineer with distillation experience for research and development at midwestern laboratories of nationally known food company. Prefer applicant having up to 8 years experience, including a good background in pilot plant development in the field of distillation problem and carries through to the ultimate design and start-up of a new process or equipment. Submit complete resume including education, work experience, and salary desired. Box 268-R, PETROLEUM REFINER, Houston, Texas.

Petroleum Refinery Chemical Engineers

Positions involving technical service and consulting type work for petroleum refineries are available in refinery technology division. Chemical engineers working in refinery process engineering or operation and economic analysis are well qualified for these positions. Positions offer a wide variety of work assignments in an expanding technical activity that works with sales, research, refinery, and company management problems. Positions also afford opportunities for industry-wide contacts with refining and process companies and for using initiative and individual expression to increase responsibility. Location in a Detroit suburb offers ideal professional environment with a choice of city or suburban living. For more particulars send name and address to:

PERSONNEL MANAGER
ETHYL CORPORATION
1600 W. EIGHT MILE ROAD,
FERNDALE 20, MICHIGAN

CHEMICAL ENGINEERS
MECHANICAL ENGINEERS
INSPECTORS & DRAFTSMEN

Positions available on the engineering staff at our new refinery, nearing completion, 12 miles south of Hattiesburg. This modern plant consists of TCC, Fluid Coking, Alkylation, Platforming, Unifining, Treating, Sulfur Production, fractionation facilities, and utilities.

Chemical Engineers:
1-5 years experience, for technical service, process design, and economics.

Mechanical Engineers:
1-5 years experience, for design, trouble shooting, construction, and estimating.

Inspectors:
To inspect equipment and maintain inspection records.

Draftsmen:
For refinery engineering drafting.

Submit resume of experience and applicable information to:

Pontiac Eastern Corp.
P. O. Box 55
Purvis, Mississippi

SITUATION WANTED

■ YOUNG ITALIAN ENGINEER. INDUSTRY SALES MANAGER in charge of the Italian Agency of an important American firm. Very well introduced in all industries especially chemicals and petroleum as well as Italian and foreign contractors. Wishes to contact important American or international firms interested in expanding their business in the European market, to be appointed resident engineer, general agent, representative, or factory manager for Italy, Europe and eventually Middle-East. Full details and references on request. Box 265-R PETROLEUM REFINER, Houston, Texas.

HELP WANTED

Unusual Opportunities in

- Engineering Planning
- Engineering Economics
- Engineering Design

The CHEMSTRAND CORPORATION, a leader in synthetic fiber manufacturing, has several openings for Chemical Engineers with more than ordinary ability.

These opportunities involve process design, engineering economics and project planning. Successful candidates will become members of a team responsible for evaluating and planning the projects that form the heart of a continuous growth program—a program that has doubled the size of this company in three years. Minimum requirements call for a B.S. in chemical engineering and five years experience in the chemical industry, petrol chemicals, process design, synthetic fibers or economics.

Send resume of complete background to:

Technical Personnel Manager,
Box E-3

The Chemstrand Corporation

Decatur, Alabama

HELP WANTED

Chemical Engineers

New staff positions, created by company expansion, are open for chemical engineers with up to ten years experience in refining or petrochemicals technical service, process control, scheduling, economics or process design. Location Corpus Christi. Write, giving resume, to

PONTIAC REFINING CORP.
Post Office Box 1581
Corpus Christi, Texas

GAS ENGINEER

For Caracas, Venezuela

CHEMICAL ENGINEERING DEGREE. MINIMUM 5 YEARS EXPERIENCE including compressor plant operations, design and operating gasoline plants and gas pipeline work. Capable setting up department when required and working with government representatives.

GOOD SALARY, ALLOWANCES, OPPORTUNITY OBTAIN ADDITIONAL EXPERIENCE AND ADVANCEMENT.

Send complete details to:
C. L. Laue

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OIL CO., INC.
150 East 42 St., New York, N. Y.

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Classified Ads Bring
RESULTS

CHEMICAL ENGINEERS
PROCESS ENGINEERING

Young men with advanced degrees in chemical engineering or at least three years' experience in process design of oil refining or chemical manufacturing facilities. Opportunities directly concerned with evaluation of research projects in the petroleum and chemical fields and design of new process units for Shell Oil Company and Shell Chemical Corporation. Located in the San Francisco Bay Area. Write giving education, experience, and personal history to Employment Supervisor.

SHELL DEVELOPMENT COMPANY
Emeryville 8, California

TAYLOR ENGINEERING AND CONSTRUCTION CO., LTD., has been appointed engineering sales representative for Graver Water Conditioning Co., New York.

The territory to be handled for Graver by Taylor will consist of the Toronto area including the majority of the Province of Ontario to the west of Toronto. Taylor Engineering has been in existence for 25 years.

TRACERLAB'S now completed in Waltham, Mass., plant brings together under one roof all of the company's East Coast consulting and technical division facilities. Previously housed in several buildings in downtown Boston, laboratory and office space will now be concentrated in one building.

Like Tracerlab's Technical division facilities in Richmond, Calif., and a laboratory in Houston, these new facilities represent modern design principles for radiochemical laboratories. Set up in two major areas, one for shielded laboratories and one for regular chemical operations, total laboratory and office area exceeds 20,000 square feet.

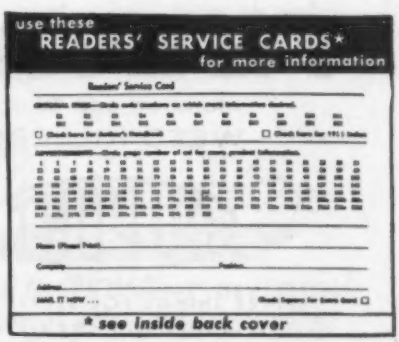
BLAW-KNOX CO. has appointed **George M. Keen** manager of the Sprinkler department, Power Piping & Sprinkler division. Keen succeeds **Harry W. Greenberg,** who is retiring but will be available in a consulting capacity.

A native of Philadelphia, Keen joined Blaw-Knox in 1937 and has been engaged principally in sprinkler sales.

HARBISON-WALKER REFRACTORIES CO. has named **Dr. Edwin Ruh** assistant director of research. He has been a research engineer in the company's Hays Laboratory and in the home office at Pittsburgh. Formerly he was engaged in research on the thermal conductivity of dense ceramics, in the school of ceramics at Rutgers University. His doctorate research on this subject resulted in a testing method which is in the process of adoption by the American Society for Testing Materials.

Dr. Ruh received each of his degrees at Rutgers.

TIMKEN ROLLER BEARING CO.'s Buffalo, N. Y., industrial and steel sales office has moved to a new building completed at 2960 Main Street in Buffalo. The change was made because of the need for additional office space and better parking facilities.



Keep areas weed-free . . . avoid fire hazards

Spray Du Pont TELVAR® WEED KILLERS just once for season-long weed control

You can eliminate weeds and grasses that create fire hazards and that make maintenance difficult and costly. Just one spray of Du Pont "Telvar" controls weeds for a season or longer. "Telvar" kills weeds through the roots, then remains in the soil to provide residual action long after the initial spray is applied. Low dosages save you cost, handling and storage space. "Telvar" weed killers are non-corrosive to equipment, non-volatile, low in toxicity to humans and animals. For low-cost, long-term control of weeds, include "Telvar" in your maintenance program.

TELVAR®
Monuron and Diuron
WEED KILLERS

DU PONT
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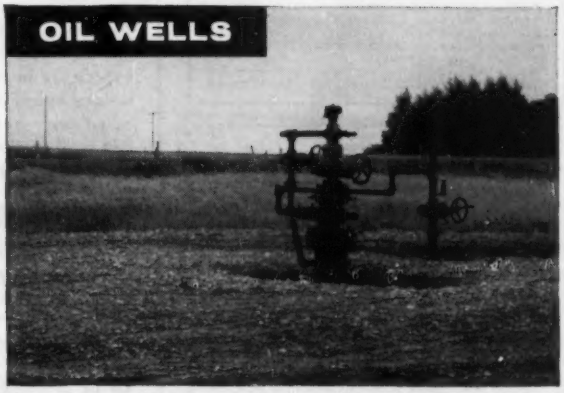
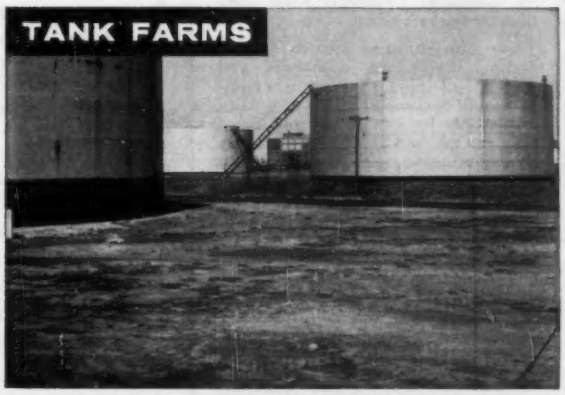
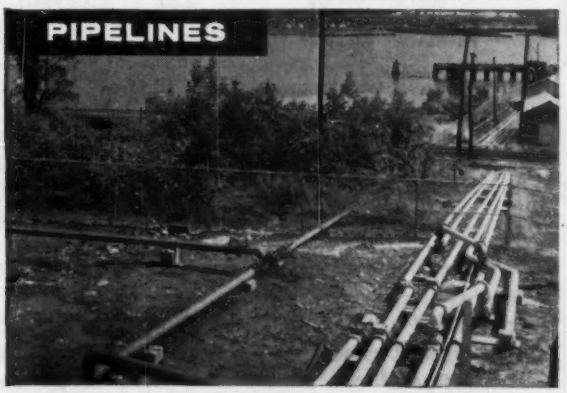
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY



Note the excellent control of weeds and grasses around this wellhead from just one application of "Telvar."



The treated area around this tank farm has remained weed-free for an entire season.



Along these pipelines, where maintenance is tough, one application of "Telvar" has kept the treated area weed-free for a year.

On all chemicals, follow label instructions and warnings carefully.

Suppliers . . .

HOOKER ELECTROCHEMICAL CO. has appointed **Hiram B. Young** vice president and **F. Leonard Bryant**, vice president-Production. Young, who has been vice president in charge of eastern production, will assume broader responsibilities with the change.

Bryant, 43, has been responsible for manufacturing operations of the Niagara plant and the Durez Plastics division plants at North Tonawanda, N. Y. and Kenton, Ohio. Both men will continue to make their headquarters at Niagara Falls, N. Y.

Young, born in Chicago, graduated from Cornell University in 1921 with a B.S. degree in chemistry. He then graduated from the Philadelphia Textile School in 1923.

After positions with Belding Bros. and Co. and Industrial Rayon Corp., he moved to the New York offices of Hooker in 1935 to work on special assignments. He was made assistant superintendent of the Niagara Falls plant in 1938, superintendent in 1941 and works manager in 1950. In 1954 he became vice president in charge of eastern production.

Born in Weymouth, Mass., Bryant graduated from Dartmouth College in 1935 with a B.A. degree in chemistry, then joined Hooker at Niagara Falls. He became assistant foreman in 1941; then foreman, Fine Chemicals; and in 1944, department head, Fine Chemicals. In 1948 he was named assistant superintendent, production, and plant superintendent in 1952. He was made Niagara works manager in 1954 and works manager for the Niagara, North Tonawanda and Kenton plants in 1955.

WOLVERINE TUBE has appointed **Del E. Wessels** technical sales representative in the Oklahoma and North Texas areas. Wessels has had varied experience in the design and rating of heat transfer equipment. He is a member of the Texas Society of Professional Engineers.

Formerly technical office sales representative in Wolverine's general sales office, Detroit, Wessels will contact petroleum, petro-chemical and chemical companies plus heat exchanger manufacturers and fabricators in that area.

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Need Engineers - Technical Personnel? Try a Classified Ad in Petroleum REFINER.

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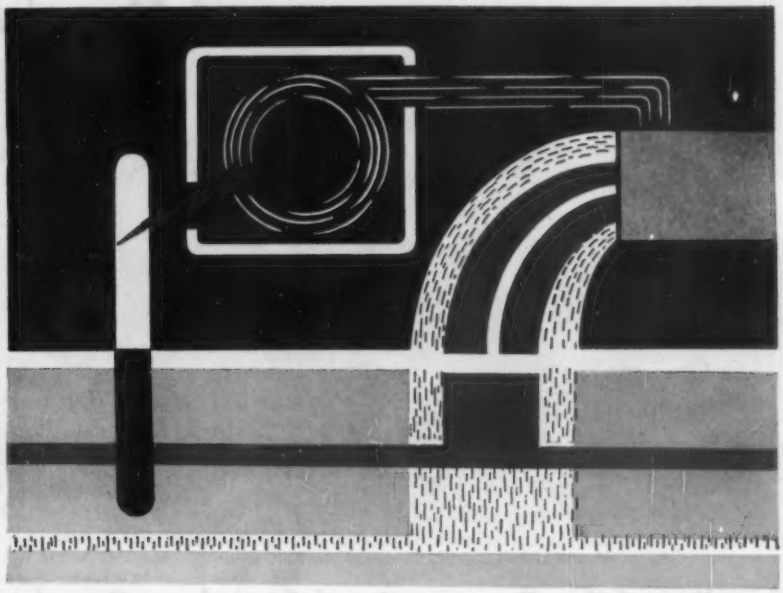


The new Fielden Pneutronic Level Control proportions flow and maintains level simply by combining an electronic "dip stick" with a proportioning pneutronic control. This dip stick has no moving parts, yet actually "senses" change in level and integrates the electronic and pneutronic units into a simple, dependable null-balance system.

Electronically, the PNEUTRONIC Level Control features the versatile electrical capacitance method of measurement. As a result, it can detect minute changes in the level of any liquid, powder, or granular solid—conducting or non-conducting. The resulting change in capacitance changes output air pressure *directly*, and this output air then feeds back to balance the electronic circuit *directly*.

FEATURES

- Null-Balance System
- Only one vacuum tube
- Control pressure 3 to 15 psi
- No moving parts in vessel
- Controls water level up to 1½" span, hydrocarbons up to 8"

SIMPLIFY RECORDING AND CONTROL WITH *Fielden*

Through interchangeable input conversion units and rebalance elements, the same basic Fielden Null-Balance Recorder can record temperature or any other process variable. Other assemblies can be added for recording up to 96 points on one circular chart, for electric control, or pneumatic proportional control. Fielden also supplies other recorders, blind on-off controllers, manual monitors, automatic scanners, and a full line of sensing elements, supplies and accessories.

Send for Literature

Mr. Controls

Robertshaw-Fulton CONTROLS COMPANY

FIELDEN INSTRUMENT DIVISION

Dept. W, 2920 N. 4th St., Philadelphia 33, Pa.

For more data on advertised products, use Readers' Service Cards, last page.

What's New in Equipment . . .

. . . and Manufacturers Literature

Stadium-Like Reservoir of Stainless Steel

Another "first" has been credited to stainless steel with the completion of the stainless lining for a two million gallon reservoir.

The 200-feet diameter concrete bowl, unused since World War I, is being re-adapted for use by Hercules Powder Co. as a storage reservoir for ammonium nitrate. Stainless steel was specified for the lining because it is highly resistant to the corrosive action of ammonium nitrate.

The relining of the tank with stainless steel followed clearance last summer of the rubble and silt that had collected in the dish-shaped tank through the years.

More than 124,000 pounds of 14 gage type 304 (AISE Code) stainless steel was used in the lining. Sixty rib-like expansion joints were pressed into the stainless and each sheet was prepared for welding. The fabricated steel for the tank lining was then assembled and welded at the job site.

The reservoir relining contract involved more than three and one-half miles of electrode welding and every inch of the work was tested with vacuum equipment. An interesting sidelight of the testing results was the revelation that in the more than 18,000 feet of welded seams handled by the field crews, only two minuscule imperfections showed up.

Before the reservoir is filled with ammonium nitrate, a final hydro-test will be made. This will be made with two million gallons of water. When the glistening steel tank is finally filled with ammonium nitrate the pressure at the bottom will be 680 lbs. per square foot. United States Steel Corp.

Circle E1 green card, last page.

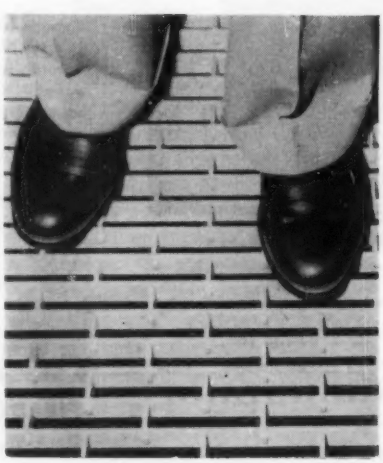
New Aluminum Grating Is Structurally Rigid

A new aluminum grating that meets the demands of the construction and maintenance industries for heavy and versatile usage has just been announced.

The RR type aluminum grating was especially designed to retain the combined advantages of a rectangular opening and riveted gratings. This grating remains structurally rigid regardless of cutouts located in any part of the panel. RR grating is easily cleaned and offers greater durability under severe load conditions.

There is a 79 percent clear opening with this striking rectangular design, so that the possibility of dirt, oil or scum accumulating in corners is practically nill. Klemp Metal Grating Corp.

Circle E2 green card, last page.



Sulfide Scale is Stopped With Aluminum Coating

A new concept in non-corrosive coatings of any ferrous-base alloys has been developed. It is a diffused type of aluminum coating that is resistant to H_2S and H_2-H_2S corrosion in furnace tubes and process lines in refinery service, particularly in reforming units.

Adherence between the base metal and the pure aluminum surface layer is accomplished by means of an alloy bond layer produced in the diffusion process. Thus, peeling of the pure aluminum surface layer is eliminated.

The bonding of the Alumi-Spra coating is effected by means of an alloy bond layer. This bond layer is produced by a special heat-treatment of the coated material at temperatures of 1250 to 1325 F, usually in an inert, oxygen-free atmosphere. In many cases the special heat treatment can be combined with the stress-relieving usually required for welds in low alloy steels.

This coating process permits the use of low-cost ferritic alloy steels instead of the more expensive austenitic stainless steels, and the cost of Alumi-Spra coatings generally is lower than any other method of aluminum coating. Chicago Metallizing Corp.

Circle E3 green card, last page.

Float Valve Bulletin

A new 16-page technical float valve bulletin has just been published.

The cushioned float valves maintain accurate water level control in elevated tanks, reservoirs, coagulating basins, mixing chambers, etc. They are designed for either cold or hot water service in either the quick opening or throttling design with integral or remote pilot control.

Parts lists, dimensions, approximate shipping weights for the various sizes, operation, installation and other pertinent information on each of the various types of float valves are contained in this new catalogue. Golden-Anderson Valve Specialty Co.

Circle E4 green card, last page.

Metal Coating from Rice Oil

A revolutionary pretreatment coating for metal surfaces has just been developed.

The basic ingredients for this new product is *rice oil*, which has amazing penetrating and adhering qualities and contains a natural wax and other properties highly resistant to corrosive action. By carefully blending rice oil with other effective solids and anti-oxidants, the company has succeeded in producing a metal pretreatment solution known as Bindox. The penetrating ability has been demonstrated to be superior to any competitive pretreatment coating known, and the tough film formed after drying offers unusual protection, particularly after customary over-coats have been added.

The unique action of Bindox has been described as somewhat similar to that of

All-welded feedwater heater for new generating station will operate at 3200 psi with inlet steam temperature of 678° F. Designed and fabricated by The Lummus Company, the unit is the first of its kind, is also the biggest heater ever built for operation at pressures above 3000 psi, having 12,710 square feet of tube surface in a single shell.

First All-Welded Feedwater Heaters Will Cut Generating Station Maintenance Costs

The first all-welded feedwater heaters ever built have been designed and fabricated by Lummus for the Linden Generating Station of the Public Service Electric and Gas Company of New Jersey. When completed, the installation will include 6 all-welded heaters, designed to operate at pressures well above 3000 psi, and 12 low pressure heaters which were all welded except for the tube to tube sheet joints.

In addition, Public Service has just given Lummus a contract to supply feedwater heater requirements for their new Bergen Generating Station, duplicating in design the Linden units.

Welded construction minimizes leaks in tubes, shell and head. Thus the new units are expected to reduce materially the costly maintenance and downtime associated with failure of seals in bolted and gasketed constructions.

These unique heaters are the end result of over ten years of design and experimental work by The Lummus Company with all-welded fabrication. Perhaps this pioneering can help you reduce maintenance problems, too. For more information write The Lummus Company, 385 Madison Avenue, New York 17, New York.

Ends of cupro-nickel tubes are jointed to steel tube sheet by Inco "140" Monel Ni-Cu alloy electrodes. This alloy fuses well with both tube and sheet materials, forms strong, sound joint.

Closed head shows torus ring seal which is welded to channel and cover. Gasketed joint has been eliminated to avoid possibility of leakage. Design water pressure of unit is 3600 psi.

LUMMUS

HEAT EXCHANGER DIVISION

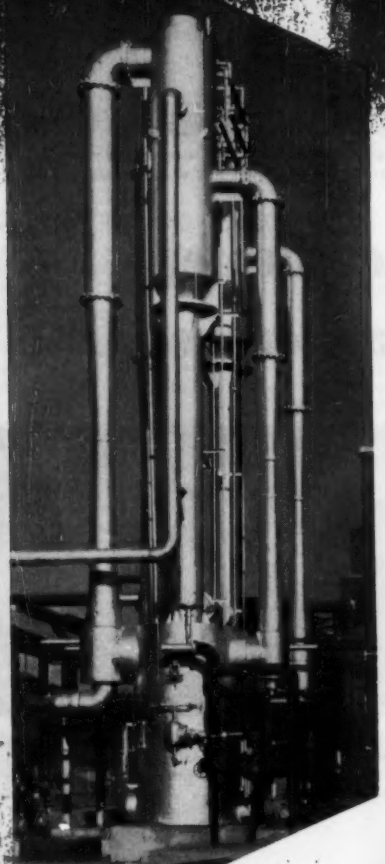
THE LUMMUS COMPANY, Heat Exchanger Division, 385 Madison Avenue, New York 17, N. Y.
Atlanta • Boston • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • East Chicago (Indiana) • Houston • Kalamazoo • Kansas City • Los Angeles • Memphis • Minneapolis Nashville • New Orleans • Newton (Iowa) • Niskayuna (New York) • Omaha • Pittsburgh Salt Lake City • San Francisco • Springfield (Mass.) • Syracuse • Toledo • Wayne (Pa.) • Athens Buenos Aires • Caracas • The Hague • Lima • London • Mexico City • Montreal • Paris Rome • San Juan

Steam Surface Condensers • Evaporators • Extraction Bleeder Heaters • Steam Jet Air Ejectors Steam Jet Refrigeration • Barometric Condensers • Heat Exchangers for Process and Industrial Use • Process Condensers • Pipe Line Coolers

For more data on advertised products, use Readers' Service Cards, last page.

LOW COST COLD WATER

(Graham Steam Vacuum Refrigeration)



If obtaining low cost cold water is going to be your headache next summer, it will pay you to let us investigate your problem now. Our recommendation costs you nothing.

The installation shown is producing 600 tons of refrigeration at 45° — and is doing it cheaper than by any other known system.

Graham

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Offices in principal cities and Canada

New Equipment . . .

blueing a rifle, in that it penetrates into the pores of the metal and combines with tight rust and oxide to form an air and moisture proof seal on the metal surface. Tests reveal that where the skin has been broken by scraping or heavy blows, there is no tendency for rust and corrosion to "creep" under the film, and by merely applying a new coat over the affected spot, rust and corrosion are immediately arrested.

It may be applied by brush, spray, roller, or dipping. It is available in three distinct formulations. Superfine Free-X for delicate instruments to be used in the same manner and for the same purposes as penetrating oils. Rapid X3-100 a pretreatment for indoor metals, and as aid in the removal of heavy rust and scale; and heavy duty Rust-X for exposed metal surfaces such as outdoor machinery and equipment, metal buildings, etc. Guardian Chemical Products, Inc.

Circle E5 green card, last page.

New Lube Additive Improves Viscosity Index

Two new lube oil additives for viscosity index improvement which are outstanding in their resistance to shear breakdown are now being offered.

Called Omavis 10 and 20, the products are the first in a new series of additives developed in the company's laboratories. Other members of the series will be announced later.

The two initial products combine the desired effects of raising the viscosity index and lowering the pour point. At the concentrations used in formulating multigrade oils, they give ASTM pour points of —30 to —50 degrees F. The Omavis additives thicken the oil less for a given viscosity index level than do similar products, thus permitting wider latitude in compounding as well as reduced use of additive. Selection of the particular additive to be used depends on the base oil.

Light colored, viscous solutions of polymers in oil, the two products are identical chemically but differ in molecular weight of the active ingredient. They are of nearly equivalent effectiveness in modifying viscosity and viscosity index when

used on an equal volume basis at concentrations of normal use. Their performance has been demonstrated in all of the accepted engine tests. Olin Mathieson Chemical Corp.

Circle E6 green card, last page.

Saran Lined Pumps Resist Corrosion

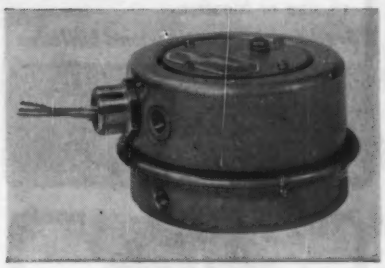
Availability of saran lined centrifugal pumps to provide completely corrosion resistant piping systems has just announced.

The new pumps, being introduced after nearly four years of extensive field testing and development, permit the handling of a broad range of corrosive liquids. They are a natural development following the wide acceptance of saran lined pipe, valves and fittings.

The two sizes available include 1½-inch x 1-inch and 3-inch x 2-inch pumps, lined completely with saran and equipped with mechanical rotary type seals. These special seals are designed to eliminate the high frictional heat failures and resultant leakage problems of packing glands. The seals are easily changeable for adapting the pumps to the handling of various corrosive fluids.

Both pumps are equipped with seal-cooling systems, and the cooling medium applied may be the fluid being pumped or water from an external source, either of which is channeled back through the pump. The Dow Chemical Co.

Circle E7 green card, last page.



New Differential Switch Operates Valves

A new differential switch has a metal diaphragm to give extremely accurate response. It comes in two classes for sensing pressure differences from 15 inches of water below atmospheric pressure to 80 inches of water above. The fixed actuation valve ranges from .2 inch of water to 2 inches of water depending on the switch setting. The reference pressure must be air or an inert gas; the variable pressure may be liquid or gas. The switch will actuate an electric circuit on an increase or decrease of a predetermined pressure difference. It can be readily adjusted by means of an external adjustment screw for field setting. This external adjustment is tamperproof to keep it from being accidentally disturbed. The switch is not sensitive to jarring or vibration and it will operate in any position—no leveling or special mounting is necessary. The unit incorporates a U. L. approved s.p.d.t. snap action switching element rated for A.C. and D.C. Recommended to operated relays, solenoids, motor controls and similar devices. A splash-proof housing protects the entire mechanism from dust or damage in exposed installations. Barksdale Valves Co.

Circle E8 green card, last page.

New Equipment . . .

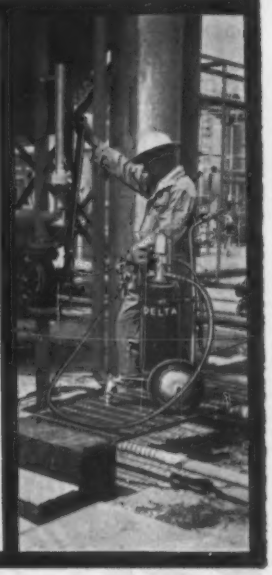
Pipefitting Protects Against Leakage

Manufacture of polyethylene demands a completely leak-proof, non-corrosive process piping system. Koppers Co. knew that Schedule 40 stainless steel pipe with conventional threaded fittings could solve corrosion problems, but wanted to avoid costly leakage at joints in a new installation. "Back welding" to eliminate leakage would require additional installation time and labor—and result, at best, in a cumbersome, unsightly job.

So Koppers chose Speedline fittings. Ex-

Speed-Up YOUR PLUG VALVE LUBRICATION

with this New DELTA "Porta-Power" PLUG VALVE LUBRICATOR



FASTER — because the operator simply snaps on the coupler of this gun, squeezes the control handle and the air motor provides full lubricant pressure *instantly — without time lag.*

BETTER — because lubricant is applied under maximum pressure by the sealed-in pump with a 70 to 1 ratio; large volume capacity insures sufficient lubricant being used.

EASIER — because the mechanical muscles of the Porta-Power eliminate hand pumping; clean, fast reloading in seconds, with 5-quart refill container; large wheels afford easy mobility even up and down steps.

DELTA-DESCO

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DELTA-DESCO COMPANIES
DELTA ENGINEERING SALES CO.
Box 1403 Shreveport, Louisiana
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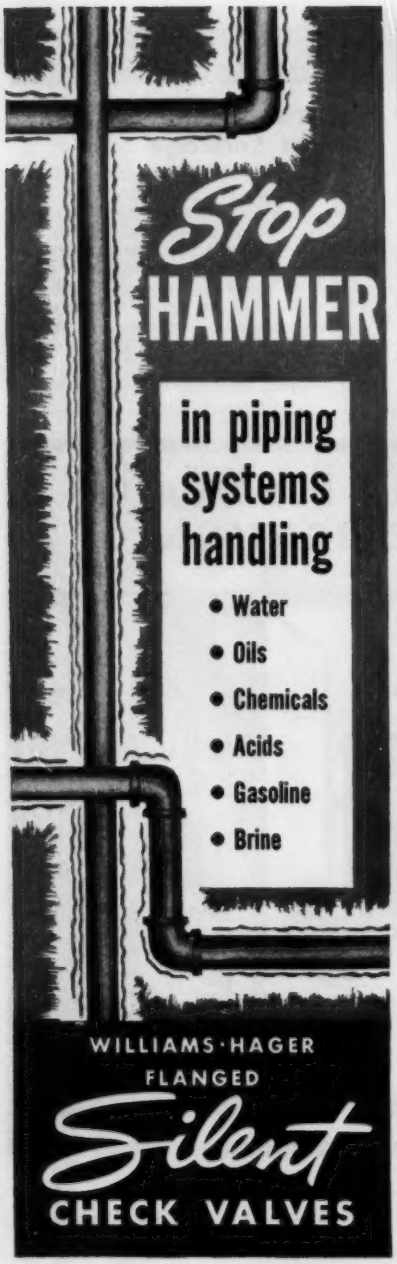

WILLIAMS·HAGER
FLANGED
Silent
CHECK VALVES

Providing dependable protection against damage from "surge pressures," these *Silent* Check Valves may be installed in horizontal, vertical and angular positions.

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No. 654 on the Valves
No. 851 on Cause, Effect and Control of Water Hammer

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New Equipment . . .

tensive tests proved to them that 100 percent protection against leakage could be accomplished with the use of these fittings and light-wall pipe. Not only was leakage avoided, but installation time was reduced by 70 percent. In addition, material costs were considerably less than they would have been for pipe wall heavy enough to allow for loss of wall thickness at the threads. H. T. Potts Co.

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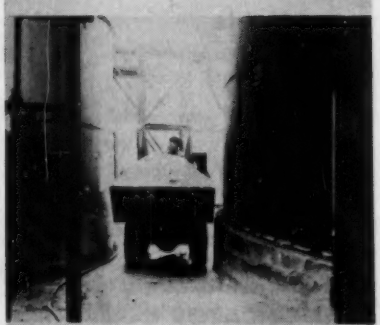

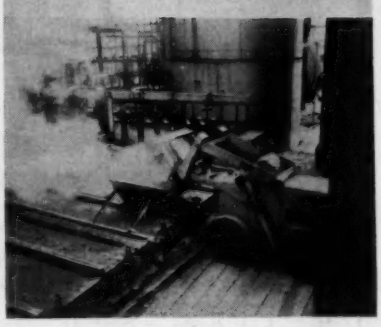

New Tractor Shovel Solves Sulfur Problem

Efficient handling of bulk sulfur required in process work of a large midwestern oil refinery is provided by a 12B tractor shovel which shuttles between stockpiled sulfur (top), between storage tanks with only inches of clearance (middle) and sulfuric acid manufacture tank (bottom). Several hundred tons of sulfur are stockpiled for use when turnaround or other maintenance of refining units cuts off the supply of recovered sulfur.

The refinery manufactures acid for use in processing petroleum. Most of the sulfur requirements are met by reprocessing spent acid and recovering sulfur impurities from the crude oil. But the reprocess supply does not meet acid manufacture

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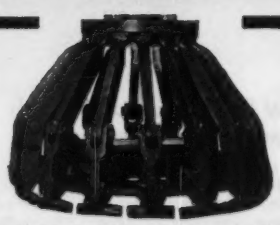

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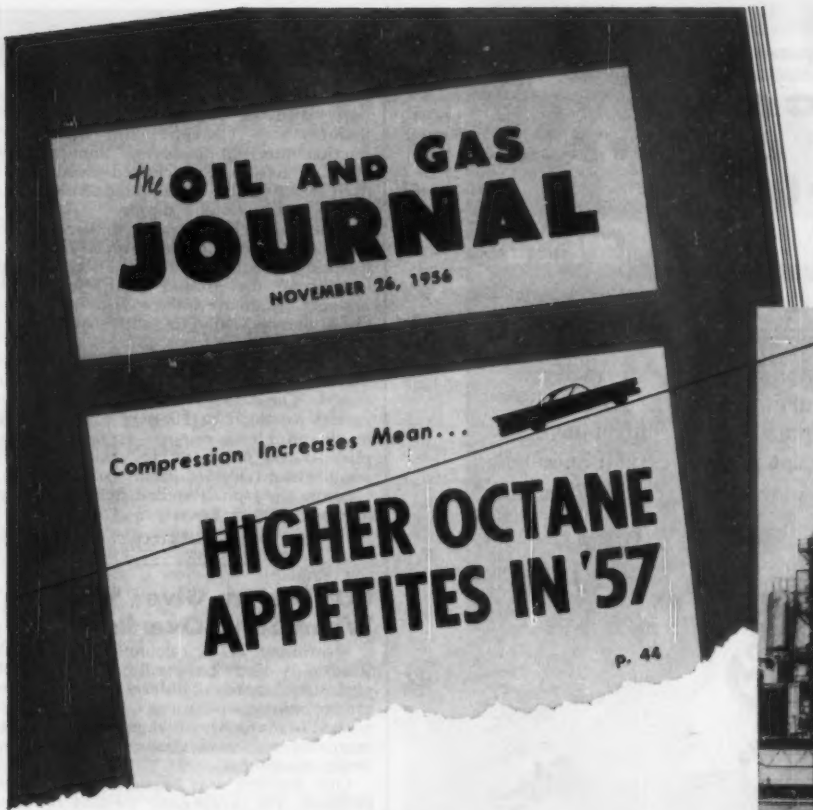

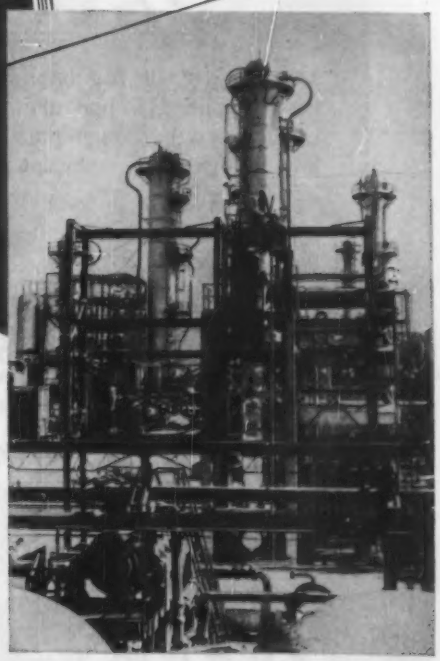

Booming high octane market spurs alkylation...

Monel resists HF corrosion... permits safe, non-stop operation for a year or more

Boosting pool octane values calls for quantity as well as quality in the premium fraction.

So, in HF alkylation, the heat's on for (1) high-stream velocity and (2) non-stop operations.

But with increases in stream velocity, the HF corrosion rate may go up. Without special protection, more inspection shutdowns are called for.

To get around the impasse producers rely on Monel

Major operators have increased their onstream time to a year or better by using Monel* nickel-copper alloy freely in critical equipment. One company reports a two-year inspection schedule.

These companies depend on Monel alloy to resist both aqueous and anhydrous HF attack at elevated temperatures and pressures.

In acid regenerators, steam reboilers, feed pre-heaters, condensers, fractionating towers... Monel alloy or Monel-clad construction provides years of trouble-free life.

In valve, pump, and instrument parts with close tolerances, it eliminates undesirable build-up of corrosion products. As relief valve rupture discs and gaskets, it helps assure safe operation.

Chances are, Monel alloy could help you increase throughput and operate safely over longer periods.

Look into the matter today. Write Inco's Corrosion Engineering Section.

*Registered trademark

When to consider Monel for HF alkylation equipment. Monel nickel-copper alloy provides useful resistance to HF in all concentrations and (in unaerated solutions) up to 250°F. It is used with the anhydrous acid at temperatures up to 1100°F. Monel is comparatively unaffected by high stream velocities. Its strength and wear resistance are high.

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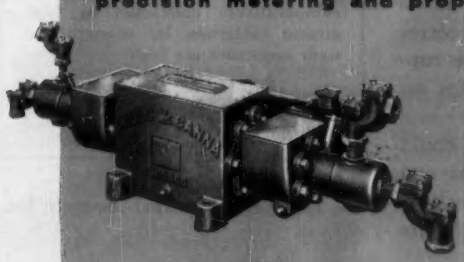

Designed for dependable, accurate metering and simplified maintenance. Complete pump details also contained in booklet offered above. Send for your copy.

Hills-McCanna Company, 2441 W. Nelson St., Chicago 18, Illinois

New Equipment . . .

requirements when one of the refining units is down for turnaround or other maintenance. To cope with these production interruptions several hundred tons of sulfur has to be stockpiled several hundred feet from the acid manufacture tanks to serve as a standby supply.

Conveying the sulfur from the pile to the tanks presented a serious materials handling problem because a steep ramp leads from the ground to the acid tank hoppers. Maneuverability also is limited by a narrow, winding path between oil storage tanks.

The refinery solved its problem by turning the carrying job over to a 12B tractor shovel. The 16-foot capacity vehicle now carries as much as 20 tons a day—or as much sulfur as is required from the stockpile. When not used for this work, it handles another difficult refinery job, cleaning up asphalt spilled during loading of trucks. Clark Equipment Co.

Circle E10 green card, last page.

CO_2 System Gives Warning When Tank Overflows

Overfilling of petroleum storage tanks is not only costly but creates great fire and explosion hazards. Fill-level indication on remote filling operations can be accomplished in a number of ways—most of them requiring communications lines or electronic equipment.

One refinery was searching for a dependable yet inexpensive method of controlling fill without use of such equipment. It installed, as a solution to its problem, a system of audio warnings—audible 1000 feet away. Units are powered by CO_2, but Freon 12, nitrogen, or compressed air may be used. Unit will sound a sharp two-minute warning to pumping crews on tankers or to land-stationed crews.

Horn system consists of a two-inch diameter steel cylinder of compressed gas about 12 inches long, pressure gage, horn assembly, and float-operated valve assembly. When liquid level in tank nears the safe filling limit, float actuates mechanical linkage to horn unit and opens valve, releasing compressed gas. Signal is rated at from 116 to 122 decibels, from 31 to 37 decibels louder than required in approved fire alarm systems.

Unit requires no outside power and is completely divorced from other warning or indicating systems.

Special weatherproof cover assemblies are available to shield the horn, valve assembly, and pressure gage from inclement weather units may be recharged from standard cylinders of compressed gas. Falcon Alarm Co.

Circle E11 green card, last page.

Rubber Industry's First Gas Turbine Operating

The rubber industry's first gas turbine has been placed in operation.

The gas turbine-generator unit, rated at 5000 kilowatts, not only furnishes the plant with electricity but also supplies heat to make process steam in a heat recovery boiler.

The simple-cycle, single-shaft gas turbine is designed for dual-fuel operation burning natural gas or distillate oil.

The gas turbine's 15-stage compressor pulls in 5.25 million cubic feet of air per

hour, and after compressing it, forces it into the combustion chamber where the fuel is injected and burned.

Expanding gases then pass through two stages of turbines which turn the compressor and the speed reduction gears which in turn are connected to the 3600 rpm generator. The turbine itself rotates at 6912 rpm.

The exhausting gases are piped through a boiler and produce 35,000 pounds of steam per hour at 250 psig and 600 F for processing applications. The exhaust gases from the turbine are still rich with oxygen and by burning additional fuel in the boiler, 120,000 pounds of steam per hour can be supplied for factory use. General Electric Co.

Circle E12 green card, last page.

Check Valves for Standard Pipe Fittings

Basic check units, which can be combined with any standard pipe fitting to form a complete check valve, are described in a new 8-page bulletin just published. Illustrations show the unit used with a reducing bushing, 45-degree ell, side outlet, drain elbow, bend and standard elbow as well as with tanks and pressure vessels. Pressure and temperature ratings are listed.

Sizes and weights are given for the basic check units, vacuum breakers and reducing couplings. The latter are used where a complete stainless-steel check valve is required. Packaging information is also included. Durabla Manufacturing Co., Inc.

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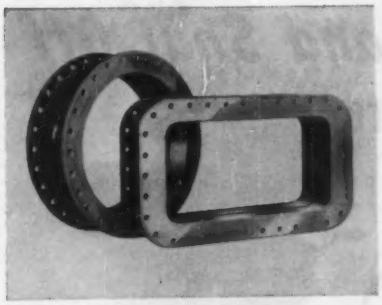

Flexible Couplings and Expansion Joints Described

Rubber, neoprene and Teflon-lined expansion joints, their construction, sizes and uses are fully explained in a bulletin just released. The bulletin describes the characteristics and limitations of seven styles of expansion joints and flexible couplings, namely (1) spool-type expansion joints, (2) rectangular-type expansion joints, (3) U-type joints, (4) all-Teflon expansion joints, (5) all-Teflon flexible couplings, (6) full-face Teflon lined rubber expansion joints, (7) expansion joints for use on piping and flanges.

The company's spool-type rubber expansion joints are suitable for handling hot or cold water, mild acids, mild caustic solutions, brine, air or exhaust steams, at temperatures to 180 F. In addition to the standard spool-type rubber expansion joints for use in connecting concentric flanges and different diameters, they can also be furnished with an eccentric taper to connect flanges for off-center piping. In addition to the high grade rubber compound, these expansion joints are also available in neoprene when they are carrying or exposed to petroleum derivatives.

Rectangular type expansion joints as described in the bulletin are available for application in pressure and vacuum lines. These joints are frequently used as a flexible connection between a turbine and a condenser.

U-type joints are primarily designed for vacuum conditions. They are made of a high grade rubber compound combined with plies of sturdy cotton duck but without steel reinforcing rings. U-type joints are made round, rectangular and in other shapes to conform with the size, contour and drilling required. The Garlock Packing Co. **Circle E14 green card, last page.**

New Equipment . . .

Free Cards Keep Complete Pump Maintenance Record

To aid manufacturers whose production involves the use of many pumps, the company has designed a pump maintenance record card which provides for complete information on installation, application and maintenance. Space is provided on each card, using both sides, to keep a complete record for a period of years—in some cases for the entire life of the pump.

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reliability

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an accessible location, are invaluable in diagnosing pump failure, in ordering repair parts, in establishing lubrication and maintenance scheduling. In addition, they are valuable in determining pump suitability for new requirements due to process changes. Notations of pump failures and the repairs required can be used to define the optimum period of any given pump before complete inspection and overhaul is required. Indicate the number of cards needed. Goulds Pumps, Inc.

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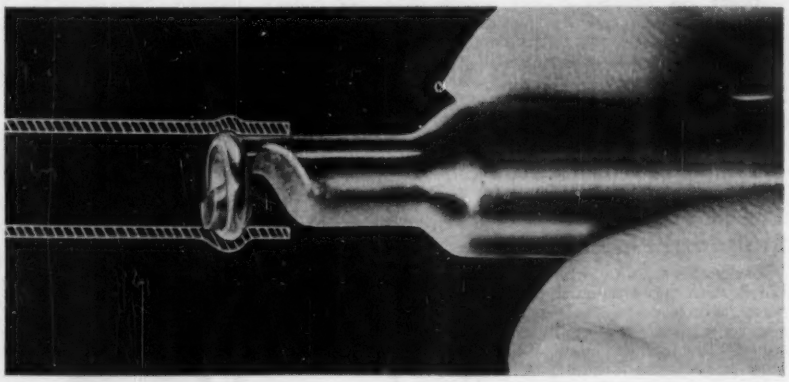
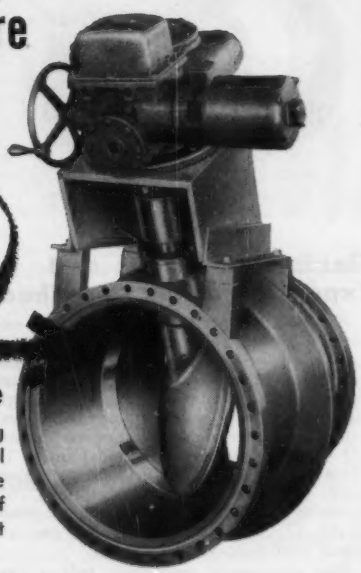


Unique Tube Fitting Makes Tight Joint

A unique fitting designed for easy installation in all types of flexible tubing requires no welding, no special adhesives, no threading. This design is reported to assure a joint as strong as the tube itself and does not reduce I.D. or flow. This easy to install tube fittings was especially designed for plastics and rubber tubing.

Making a tight, strong fitting is completely mechanical. The fitting (elbow, tee, 90 degree or special design) is slipped on tube. Using the special ring holder, a non-corrosive ring is inserted into the tube. Tightening the molded nylon fitting completes the operation. The joint is

for Throttling and Shut-Off
at HIGH Temperature and HIGH Pressure



Stress Sealed Butterfly Valve

Costs Less — Saves Space

Unique W. S. Rockwell pressure sealing arrangement enables disc to seat full 360° against inflated alloy band in valve body, practically eliminating leakage of gases even at 800°F. or higher and at pressure to 250 psi.

Illustrated is a 30" valve with motor operator; other sizes to 132".

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With Oakite chemical circulation method you can now clean heat exchangers in place. And here are a few of the many advantages awaiting you:

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For the complete story on heat exchanger cleaning by Oakite send for new 48-page Booklet "What Petroleum Men Should Know to Simplify Cleaning". Or write for the name of your local Oakite Technical Service Representative. No obligation. Oakite Products, Inc., 44C Rector Street, New York 6, N. Y.

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Leakproof
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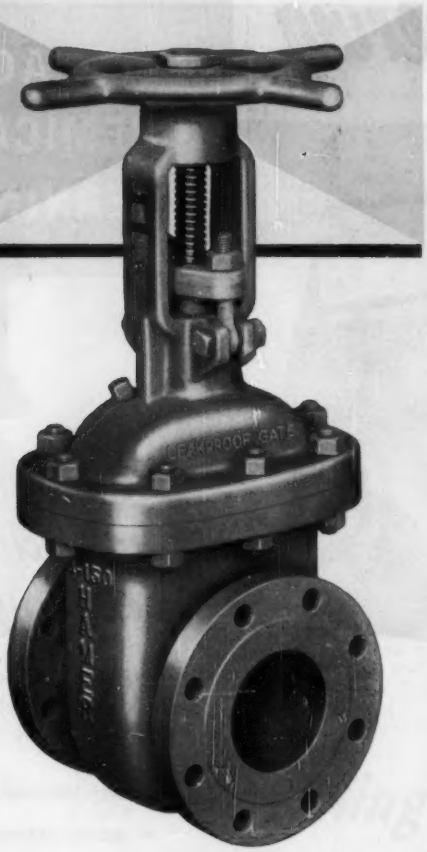
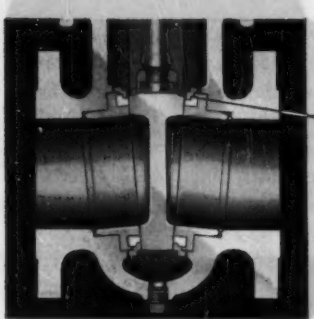


Impenetrable Shut-off Upstream —Downstream

This new Hamer Gate Valve incorporates a double sealing action design that's both absolute and foolproof. In addition to the precision metal to metal fit of the wedge, the Hamer Gate Valve incorporates two Teflon* seal rings which compress dead tight against the wedge. Thoroughly proven under the most rugged field condition tests, the Hamer Gate Valve with its positive shut-off both upstream and downstream, eliminates the need for a double block and bleed in piping installations.

Hamer Gate Valves incorporate a new high standard of valve production. Stainless steel valve seats are welded-in for accurate fit. Locking rings are of corrosion resistant stainless steel. And precision finish on critical parts assure a smooth operating valve even after years of hard service. Write today for literature. See for yourself why Hamer Gate Valves are truly **a valve without equal.**



Double Sealing Action forms Impassable Shut-off

TEFLON SEAL RINGS... Renown for their inert characteristics, these Teflon seal rings have amazing durability even under the most adverse of service conditions.

PRECISION FINISHED GUIDES... Wedge guides are machined to exacting tolerances. Eliminates chatter and wear caused by line pulsations, accurately centralizes the wedge between the seats.

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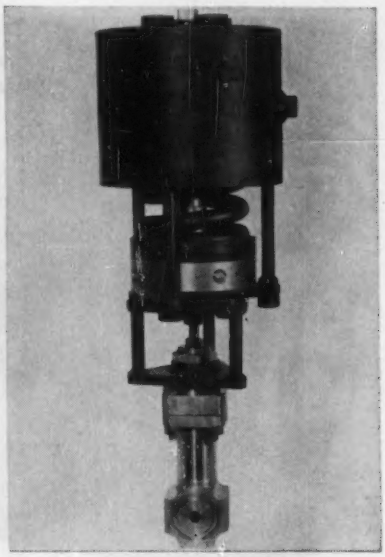

All-Metal Actuators Operate Control Valves

A complete line of all-metal actuators for control valves has been developed for use under difficult conditions such as high temperatures and corrosion.

Much of the early design and engineering work on the actuators was undertaken for nuclear reactor experiments at Oak Ridge, Tenn. According to the company, several of the actuators have been in use for some time at atom installations throughout the country.

The new actuators are available with suitable valves as complete control units, or as additions to existing valve installations. Some are designed to function either "air to open" or "air to close" and are easily reversible in the field.

For use in highly corrosive atmospheres, one model is manufactured with stainless bellows and stem. Its frame is made from cold rolled steel which has been cadmium plated. It is available in three ranges of signal pressures: 3 to 15 PSI; 6 to 30 PSI, and 9 to 45 PSI. Possessing a maximum thrust of about 3000 pounds, the actuator is compact in size, measuring 17 9/16 inches in length and 8 5/8 inches in diameter. One unit, available "air to close" only, is fabricated completely of stainless steel.

The line of actuators also includes smaller models and those for use in less critical situations. Robertshaw-Fulton Controls Co. **Circle E17 green card, last page.**

Catalog Covers Remote Control Loading

A completely revised condensed 28-page catalog (C-5000, Rev. 8) covering meters, regulators and valves has just been introduced.

Outstanding new features of the catalog

a graphic presentation of a dynamic industry

highlighting the extent of engineering and construction services available to every phase of petroleum processing.

describing a cross-section of performance, accomplishment and over-all contribution to the industry.

showing how expert contract management can relieve you of the multiplex burdens encountered in completing a project.

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New Equipment . . .

include photo-illustrated descriptions of recently introduced telapilot with power pilot loading by remote control—and the Hypregun, a light compact, efficient air-operating valve lubricant gun.

The catalog also includes completely revised valve specifications and is completely restyled throughout, with new emphasis on the use of photo illustrations of all major products described. Rockwell Manufacturing Co.

Circle E18 green card, last page.

Dry Acid Compound For Metal Cleaning

A new powered acid material which removes rust, scale and corrosion with greater safety to metal surfaces as well as personnel, has recently been introduced.

Added to water in concentrations upwards of eight ounces to the gallon, Drycid is said to go into solution fast and to be useful in applications by circulation or immersion. Solutions of the compound may be used cold or for faster action, heated to 165 F. It is said to be effective in the removal of scale, scale-like deposits, rust, iron sulphides and other oxides.

Major advantages of this new material include its ease in shipment and in storage, as it requires no returnable carboys but is shipped in fiber drums; its mild, aromatic odor and nonfuming characteristic; its greater safety on aluminum, brass and galvanized surfaces, when used as recommended. Oakite Products, Inc.

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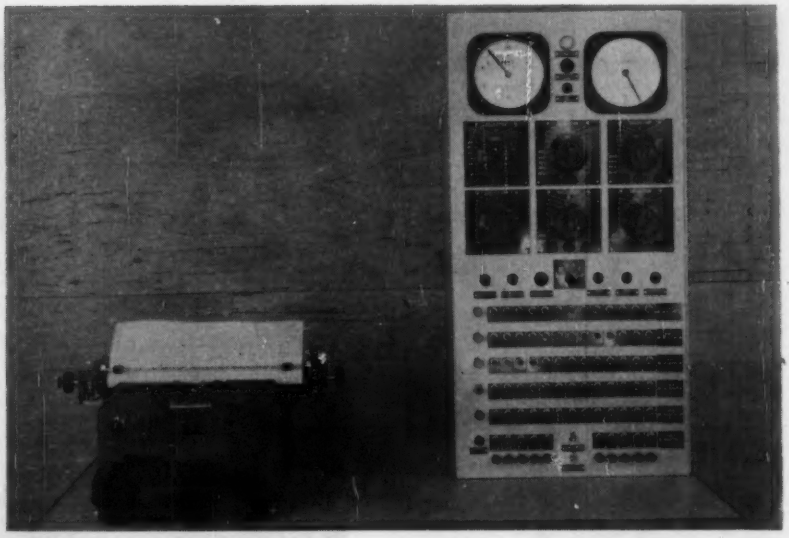

New Equipment Monitors Tank Level Accurately

The central control station and electric typewriter will be installed in a large oil refinery. Liquid levels in 72 large storage tanks are automatically logged each half hour with one-eighth-inch accuracy (1 part in 5000 or better).

Each tank is equipped with an Automatic Level Gage and Telepulse Transmitter. Upon interrogation, this unit responds with a unique identification code corresponding to its address and then sends level in feet, inches and eighths. Bursts of fixed-width pulses at 8 pps are generated by cam switches and received by stepping relays. No vacuum tubes or transistors are used and all circuits are designed to "fail safe." Digital transmission up to 1000 miles over one wire (earth return) does not degrade accuracy. Low cost, telegraph-quality lines of 75 cps bandwidths are satisfactory.

Continuous-supervision alarm circuits warn of dangerously high or low levels, and the Datalogger prints these data in red. Temperature, pressure and other physical variables may also be logged, and similar alarms provided. Motors, valves

Your
STRUCTURAL STEEL and
STEEL PLATE FABRICATION
ON TIME!

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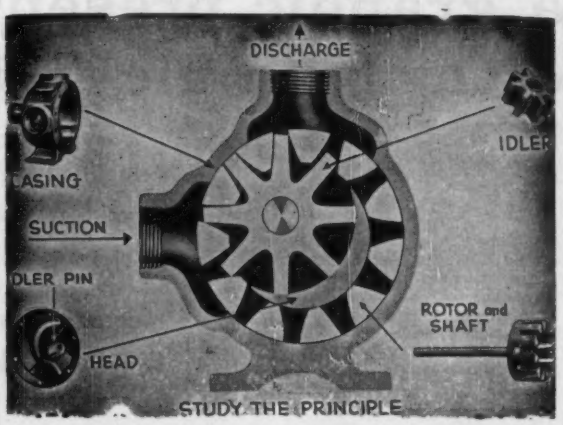
ST. MARY IRON WORKS
Steel Fabricators for over Half a Century
FRANKLIN, LOUISIANA PHONE 820

Viking Operating Principle



Above are illustrated the major parts of the Viking Pump—casing, head, rotor and idler, separately and assembled. Imagine the rotor and idler in motion operating in a counterclockwise direction. Follow the course of the liquid from point of suction to point of discharge. Reverse direction will operate equally well. We invite your inquiries.

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Save on transportation costs, manufacturing time and put yourself in a more competitive position by contacting an experienced "on the spot" source when planning the procurement of process and plant equipment for the West Coast. Send prints for prompt quotation on your next job.

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Craftsmen in steel plate and alloys up to 1"

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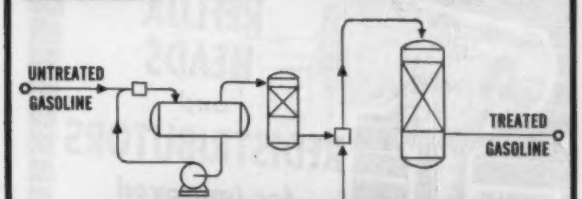

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Tennessee's Copper Chloride was developed to effect efficient Mercaptans removal.

Place your confidence in a basic producer of Copper Chemicals.

CUPRIC CHLORIDE DI-HYDRATE

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For samples make request on your company letterhead.

TENNESSEE TC CORPORATION

617-629 Grant Building, Atlanta, Ga.

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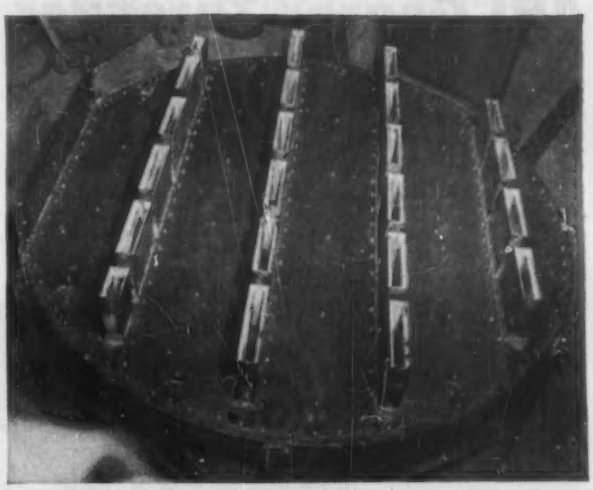

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Now you can equip fractioning towers with internals fabricated of Hendrick perforated metal plate. Hendrick "custom-tailors" perforated metal decks in commercially rolled metals and gauges to meet your own detailed specifications. Modern Column Internals produce greater capacity . . . reduce high cleaning and replacement costs caused by fouling and corrosion. And they're fabricated of Hendrick's own perforated metal . . . clean cut perforations assure uniformity of mesh and long service life. For more detailed information mail the coupon below and let us set up a date to meet with your process designer.

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For more data on advertised products, use Readers' Service Cards, last page.

New RIDGID 4PJ Geared Threader is now * JAM-PROOF

Patents Applied for

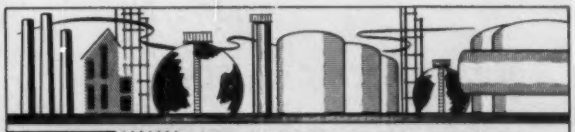
*Automatically Stops Threading After Standard Length Thread Is Cut

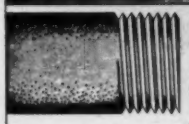
Power drive threading is safe and easy with this new 4PJ—no more watching of either die stock or drive! 4PJ can't jam—drive pinion kicks out automatically after full thread is cut. Extra-easy to handle . . . mistake-proof workholder, no bushings . . . fully enclosed gears . . . RIDGID most-for-your-money—Buy new 4PJ at your Supply House!

RIDGID 400A Power Drive with Universal Drive Shaft operates 4PJ Threader on 2½" to 4" pipe held in Tristand Chain Vise, all RIDGID products.

The Ridge Tool Company, Elyria, Ohio, U.S.A.

RIDGID
Work-Saver Pipe Tools





Troubled With High Temperature Threaded Connections?

MOLYKOTE® Type G Lubricant Offers Nearly 100% Safety Against Galling and Seizing

The annual cost of repairs due to galling and seizing of high temperature threaded connections runs into fantastic figures. One oil refinery estimates a yearly expenditure of $60,000 due to this cause. Many of the top refineries are presently using MOLYKOTE, Type G, to practically eliminate these problems.

In test after test, MOLYKOTE has shown the best qualifications as a thread lubricant because it combines these important characteristics:

1. Make-up and break-away torque amazingly reduced.
2. MOLYKOTE, Type G, suitable for high or low temperature threaded connections on bearing surfaces.
3. Galling and seizing practically eliminated.
4. Excellent chemical stability. Resists all but a few strong and concentrated acids.

Send today for Lubrication Newsletter #2

The ALPHA MOLYKOTE Corporation

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71 Arnulfstrasse, Munich 19, Germany

Pat. Pending

AUTOMATIC REFLUX HEAD

Explosion-proof, electrically-operated for high vacuum, pressure and temperature, and for corrosive and hazardous service. Eliminate reflux control problems with its simple, accurate and dependable operation.

COLUMN REDISTRIBUTOR
PAT. NO. 2,639,130

Distributes liquid evenly over the packing and minimizes channeling. Improvements to 100% in plate efficiency are usually possible. Especially suitable for vacuum distillation. Readily installed in existing installations.

Reflux Heads and Redistributors are available in most metals and made in all sizes including large diameters. For further information write for Bulletin No. 55-1.

DISTILLATION ENGINEERING COMPANY

**109 DORSA AVE.
LIVINGSTON,
NEW JERSEY**

and actuators may be remotely supervised and controlled by the same equipment. Shand and Jurs Co.

Circle E20 green card, last page.

Inhibitor Treatment Cost Calculator

A chemical additive calculator has recently been developed. We are certain that you will find this a useful and convenient aid in calculating additive treatment rates and costs for various chemicals.

An example of the use of this calculator is as follows:

A petroleum refiner contemplates using 20 ppm of Duomeen T as a corrosion inhibitor in a light distillate. The Duomeen T requirements and treatment costs for this operation would be calculated as follows:

Step 1. Set 20 ppm on scale "1" directly below 42 gal./bbl. (the petroleum industry uses 42 gallon barrels). Directly above the arrow on scale "1", you will then read **0.84 gallons** of additive (Duomeen T in this case) per 1000 barrels of light distillate.

Step 2. Without resetting the scale, locate the additive weight/gallon (6.8 lbs./gallon for Duomeen T @ 75° F) on scale "2" and read **5.7 lbs.** of Duomeen T per 1000 barrels of light distillate.

Step 3. Turn the calculator over and reset the slide so that additive pounds/1000 barrels (5.7 pounds in this case) is directly below the additive cost per pound, on scale "3" ($0.38/lb. for Duomeen T in tankcars). Read the additive treatment cost in cents/bbl. or mills/bbl. on scale "4." Treatment costs in this example are 0.22c or 2.2 mills per barrel. Armour Chemical Division, Armour and Co.

Circle E21 green card, last page.

Corrosion Resistant Metals Described in New Guide

A new 12-page Corrosion Guide is now available to users of corrosion resisting processing equipment as a handy reference chart. Use of this comprehensive guide can be of inestimable value in determining the types of corrosion resisting metals to be considered in processing equipment which is subject to chemical corrosion. Misco Fabricators, Inc.

Circle E22 green card, last page.

New Equipment . . .

Bulletin Describes Use of Microballoon Spheres

A new Technical Bulletin MB-110 contains instructions for the use of Microballoon Spheres on tanks with mixers. A representative table for an intermittent mixing cycle where the mixer is operated during both the filling and emptying cycles is included in this bulletin. Colton Chemical Co.

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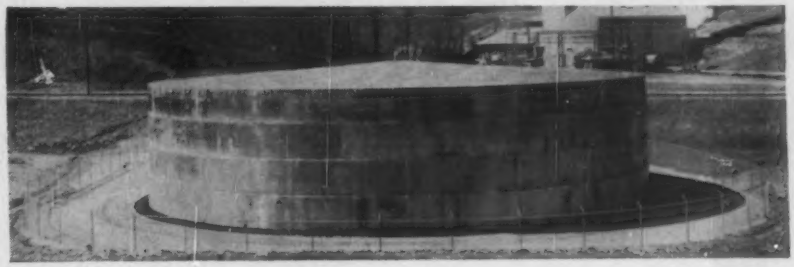
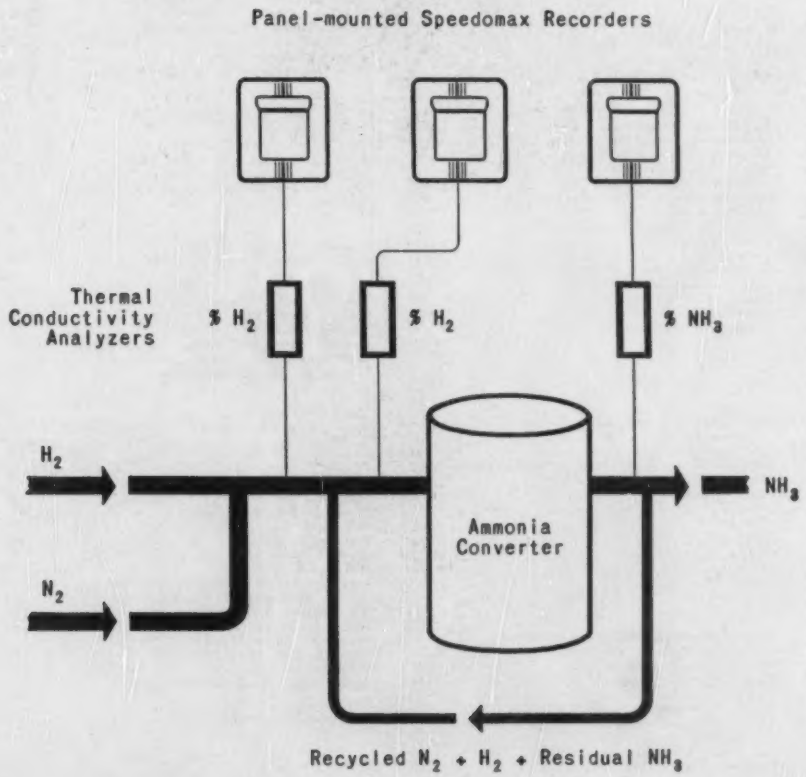


Aluminum Storage Tank

The largest aluminum tank ever fabricated and erected by this company was recently completed for the Mississippi River Chemical Co.'s storage area at Crystal City, Mo. The tank is 100 feet in diameter, 23 feet, 2½ inches high, and is fabricated from 5052-H112 aluminum plate over interior structural members of 6061 aluminum.

The field construction department used the metallic inert gas shielded welding process to erect the tank. The chemical company will use the new vessel for storing 83 percent ammonium nitrate solution. Nooter Corp.

Circle E24 green card, last page.



Ammonia Yield Boosters

In one modern synthetic ammonia plant thermal conductivity analyzers and electronic recorders are playing an important role in keeping ammonia yield high. Because of the accurate measurements furnished by these instruments, the refinery can maintain the precise hydrogen-nitrogen ratio that is essential to process economy.

The hydrogen-nitrogen ratio is so important that two identical analyzers are used on the feed stream, one before and one after the entry of recycle gas, as shown in the drawing. They continuously measure the percentage of hydrogen, in the range of 65 to 85 percent. A third analyzer, calibrated from 0 to 20 percent NH_3, measures the ammonia yield from the converter and the amount returned in the recycled gas stream.

Plant operators have found that the analyzer-recorder system operates with remarkably little maintenance. This is due primarily to the basically simple design of both the L&N analyzer and the Speedomax electronic recorder. Because these analyzers operate on the thermal conductivity principle, they measure gas composition directly, rather than inferentially. A Wheatstone bridge circuit measures the resistance of a heated wire surrounded by the sample gas. One arm of the bridge contains a measuring cell through which the sample flows; the other arm, a reference cell filled with a standard gas. Leeds & Northrop Co.

Circle E25 green card, last page.

For more data on advertised products, use Readers' Service Cards, last page.

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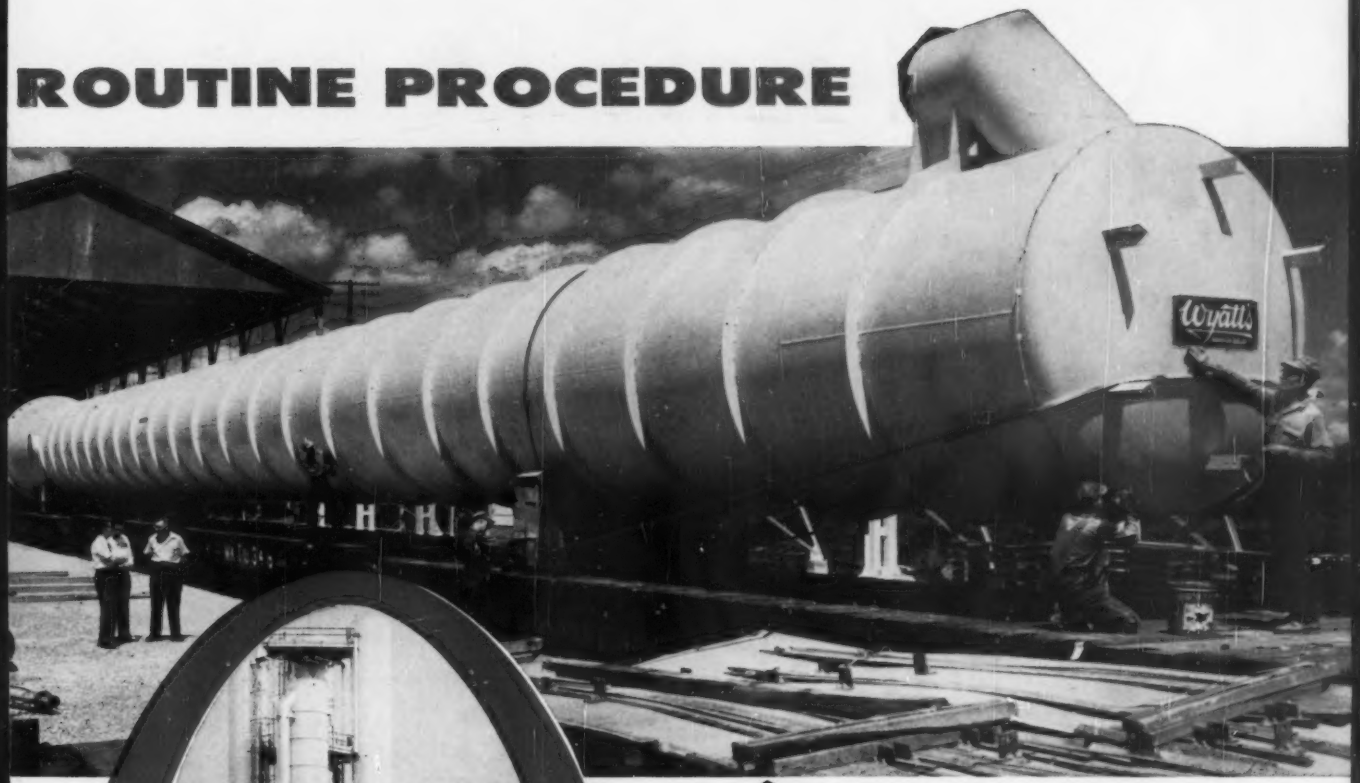
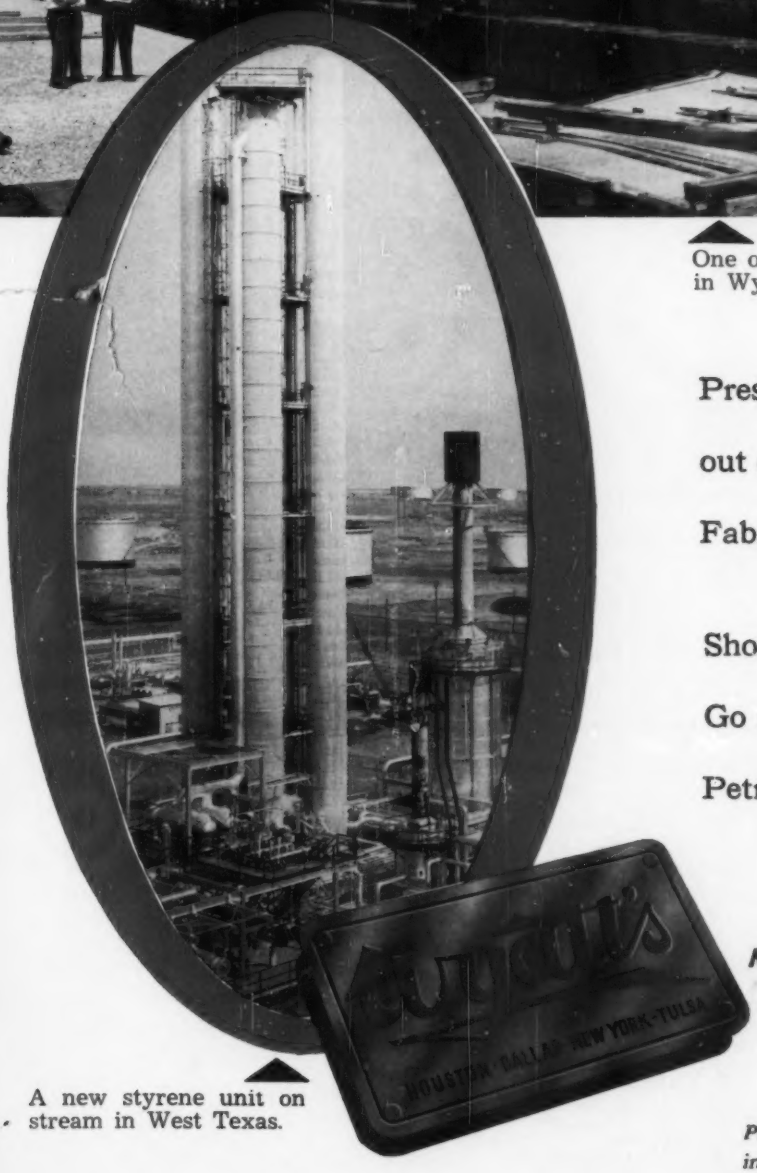


One of the four towers fabricated in Wyatt's Houston shops.



A new styrene unit on stream in West Texas.

Pressure Vessels move

out of Wyatt's

Fabrication Shops

Shortly New Units

Go on Stream in

Petrochemical Processing

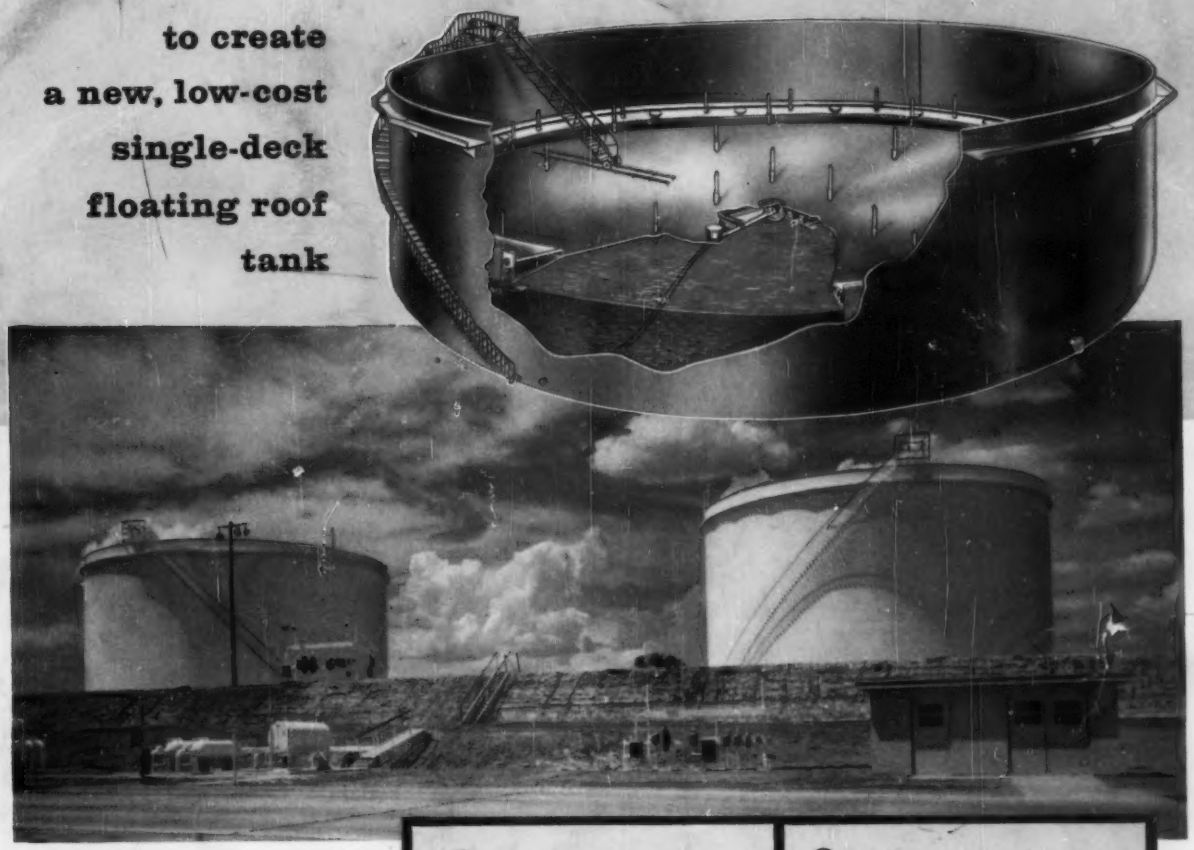
MANUFACTURERS AND ERECTORS SINCE 1913

Plastic Lining is the Growing Trend in Mastering Corrosion...
Consult **WYATT'S PLASTICS, INC.**
Subsidiary, Wyatt Metal & Boiler Works

Another 100th Anniversary Achievement!

WE'VE PUT THE CENTER WEIGHT UNDER THE DECK

to create a new, low-cost single-deck floating roof tank



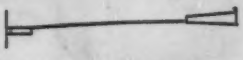
OUTSTANDING FEATURES

The long-established advantages of Graver's patented single-deck floating roof principles are enhanced by putting the center weight *under* the deck. This clears the deck for positive drainage and easy snow removal. It also effects economies in construction without sacrificing traditional Graver quality. Ask about this new Graver first, available in both the pontoon and pan types.

1 SELF-DRAINING

Rainfall flows to the Graver sump at the center low point of the roof.

2 CORROSION-RESISTANT



The liquid in storage is always in full contact with the deck.

3 STABLE

Ship-like, the center of buoyancy is below the center of gravity.

4 VAPOR-STOP SEAL

Features Graver's patented single seal, long proved effective against vapor loss.

1857-1957 GRAVER *Our 100th Year*

Building for the Future on a Century of Craftsmanship in Steels and Alloys

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA • NEW YORK • PHILADELPHIA • EDGE MOOR, DELAWARE
PITTSBURGH • DETROIT • CHICAGO • TULSA • SAND SPRINGS, OKLAHOMA
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